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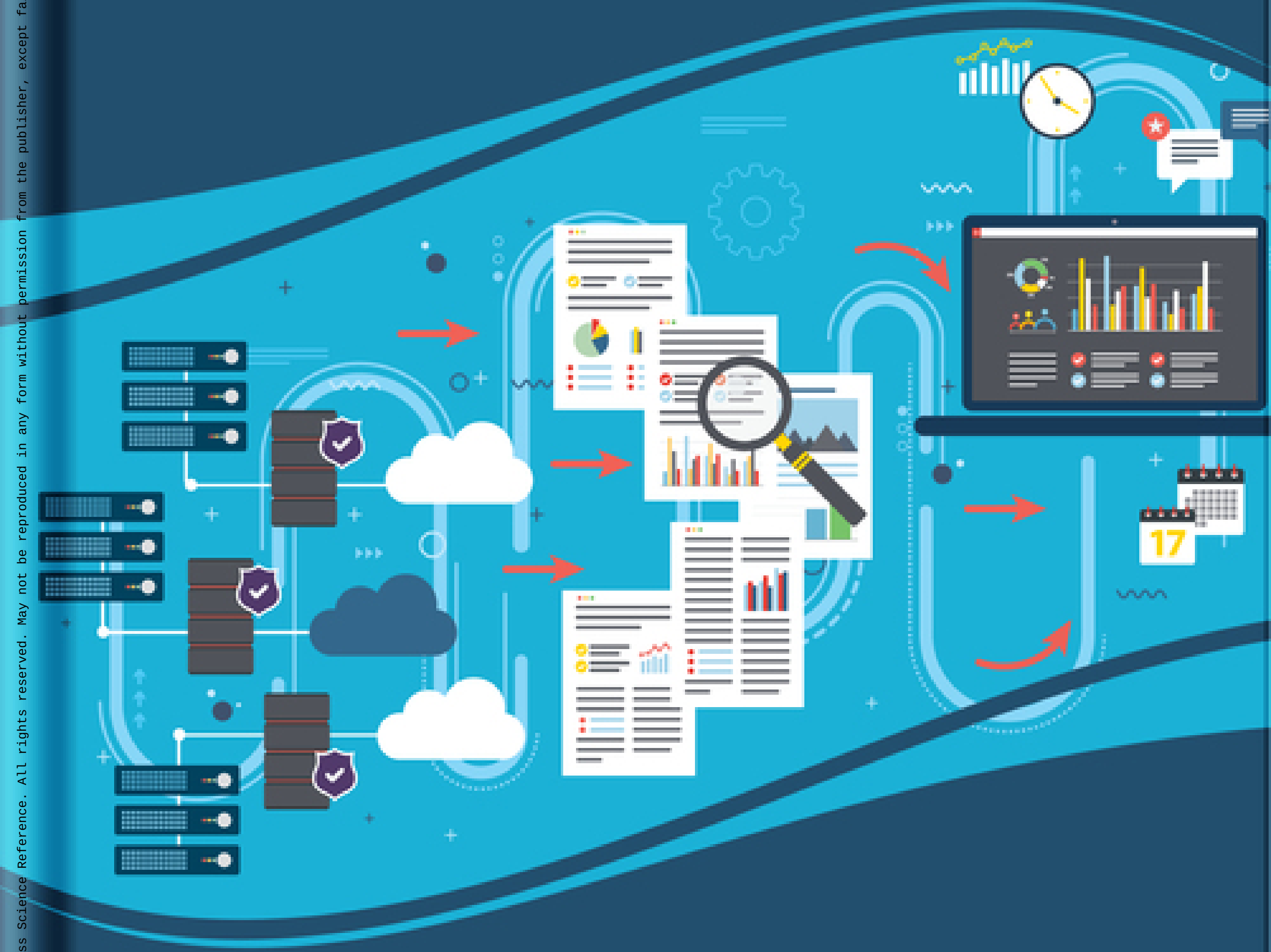
Knowledge Management, Innovation, and Entrepreneurship in a Changing World



Murray Eugene Jennex

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Knowledge Management, Innovation, and Entrepreneurship in a Changing World

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A volume in the Advances in
Business Strategy and Competitive
Advantage (ABSCA) Book Series

Published in the United States of America by
IGI Global
Business Science Reference (an imprint of IGI Global)
701 E. Chocolate Avenue
Hershey PA, USA 17033
Tel: 717-533-8845
Fax: 717-533-8661
E-mail: cust@igi-global.com
Web site: http://www.igi-global.com

Library of Congress Cataloging-in-Publication Data

Names: Jennex, Murray E., 1956- editor.
Title: Knowledge management, innovation, and entrepreneurship in a changing world / Murray Eugene Jennex, editor.
Description: Hershey, PA : Business Science Reference, [2020] | Includes bibliographical references and index. | Summary: "This book analyzes global aspects of knowledge management from differing cultural perspectives and their use of knowledge and knowledge management. It focuses on the technical issues associated with the creation and implementation of knowledge systems utilizing artificial intelligence, entrepreneurial, and innovative initiatives"-- Provided by publisher.
Identifiers: LCCN 2019039197 (print) | LCCN 2019039198 (ebook) | ISBN 9781799823551 (hardcover) | ISBN 9781799823568 (paperback) | ISBN 9781799823575 (ebook)
Subjects: LCSH: Knowledge management. | Knowledge, Sociology of.
Classification: LCC HD30.2 .K63748 2020 (print) | LCC HD30.2 (ebook) | DDC 658.4/038--dc23
LC record available at https://lccn.loc.gov/2019039197
LC ebook record available at https://lccn.loc.gov/2019039198

This book is published in the IGI Global book series Advances in Business Strategy and Competitive Advantage (ABSCA) (ISSN: 2327-3429; eISSN: 2327-3437)

British Cataloguing in Publication Data
A Cataloguing in Publication record for this book is available from the British Library.

Advances in Business Strategy and Competitive Advantage (ABSCA) Book Series

ISSN:2327-3429
EISSN:2327-3437

Editor-in-Chief: Patricia Ordóñez de Pablos, Universidad de Oviedo, Spain

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Section 2
Application of Advanced KM

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Competitive advantage in today's advanced economies is driven by innovation and the ability to manage ever-increasing forms of knowledge on a sustained basis. Knowledge-intensive industries compete primarily on their capacity to innovate and thrive on cutting-edge knowledge, which drives both research and innovation. Knowledge-intensive organizations constantly seek to reinforce sustainable links between forms of knowledge and modes of innovation. In such a dynamic environment, the proactive management of knowledge assets is essential to achieving both innovation capability and innovation performance. Since knowledge-intensive organizations play a significant role in value creation through innovation, the ways in which organizations approach knowledge management (KM) influences innovation and becomes a source of competitive advantage. As such, KM emerges as an essential management and organizational capability in the drive to create value through knowledge. This chapter explores the ways in which KM contributes to systematic innovation capability in knowledge-intensive organizations.

This chapter reviews examples of how technologies that support knowledge management (KM) can link it to entrepreneurship, and in doing so, can increase the possibility of connecting domains that have traditionally been separated, both in the literature and in the practice of entrepreneurship. In particular, authors describe the utilization of KM processes and tools in a variety of organizations. They also link extant models of processes that support KM and entrepreneurship and propose their integration. Previous work examined the uneven track record of KM utilization in entrepreneurial organizations. In this analysis, authors take a broader view of its application with a specific eye towards KM technologies and by linking entrepreneurial and KM processes of new ventures.

This chapter provides important empirical evidence to support the role of individual knowledge management processes and separate innovation types within firms. Specifically, knowledge acquisition and knowledge application are analyzed and empirically tested in relation to product and process innovation as well as business performance. The results support the direct impact of product and process innovation on business performance. In addition, the results show the indirect effect of knowledge acquisition and knowledge application on firm business performance through product and process innovation.

The basis for improving the quality of human capital in the framework of building a digital economy is the creation, mass implementation, and widespread use of digital intelligent systems in the business processes. This chapter develops the fundamental foundations of increasing the efficiency of using digital technologies and building the enterprise's information and computing infrastructure for embedding intelligent decision support and knowledge management systems in the organizational management system, which will contribute to the growth of labour productivity and increase the intellectuality of jobs. It is shown that the decisive role is played by artificial intelligence methods: intellectual analysis and modelling, decision support systems, learning avatars using neural networks, and geoinformation systems. A special role in the chapter is given to knowledge management methods, it is shown that the effectiveness of their use depends on how different economic agents acquire, generate, disseminate, and use new knowledge necessary for successful management activities.

This chapter focuses on ubiquitous sensing devices, enabled by Wireless Sensor Network (WSN) technologies, that cut across every area of modern day living, affecting individuals and businesses and offering the ability to measure and understand environmental indicators. The proliferation of these devices in a communicating-actuating network creates the internet of things (IoT). The IoT provides the tools to establish a major global data-driven ecosystem with its emphasis on Big Data. Currently, business models may focus on the provision of services, i.e., the internet of services (IoS). These models assume the presence and development of the necessary IoT measurement and control instruments, communications infrastructure, and easy access to the data collected and information generated. Different business models may support creating revenue and value for different types of customers. This chapter contributes to the literature by considering, innovatively, knowledge-based management practices, strategic opportunities and resulting business models for third-party data analysis services.

Both information systems outsourcing and knowledge management are well-established business phenomena. Regardless of organisational reasons for information systems (IS) outsourcing, knowledge remains the single most important resource for organisations to be managed. In an attempt to provide tactical mechanisms for creating and managing shared knowledge in organisations embarking on IS outsourcing arrangements, this chapter focuses on the design and application of a knowledge framework for IS outsourcing, with the purpose of guiding organisations in their knowledge exchange planning through concrete mechanisms, practical steps, and validation. Key considerations for information systems outsourcing is mapped to critical success factors, each associated with a set of knowledge requirements and knowledge flows to support the successful achievement of a specific critical success factor. An associated assessment tool was designed to identify knowledge exchange mechanisms and potential issues and gaps in current or future information systems outsource arrangements.

Knowledge Societies strive to better their citizens by maximizing services while minimizing costs. One of the more expensive activities is conducting a census. This chapter explores the feasibility of conducting a smart census by using a knowledge management strategy of focusing on actionable intelligence and the use of open source data sources to conduct a national census that collects data to answer the issues the census is designed to address. Both technical and data privacy feasibility is discussed.

The areas Project Management and Knowledge Management include studies on the project and project team levels, but a specific focus on the role of the Project Manager in managing knowledge within the team has received less focus. The authors show how knowledge is created within the project team environment, and the specific role of the Project Manager as an individual uniquely situated to drive the creation of knowledge in the environment by facilitating, directing, and controlling team activities through the four SECI model phases. Using a single case study approach, this research shows how the PM acts as a "mixing valve" in the flow of knowledge in a dynamic, multi-directional, process within the project team environment.

Agricultural KMS development involves various participants from different communities of practice (CoPs) who possess their own knowledge. However, the current development of technology neglected the local communities who possess indigenous knowledge, which is the key success factor for agricultural development. This chapter discusses how to integrate scientific and IK in agricultural KMS development and use. An interpretive analysis of primary qualitative data acquired through in-depth, semi-structured interviews and participant observations was carried out following system development action research approach. The research result yields concepts for understanding the process conceptual framework in KMS development and use for knowledge sharing and integration.

Preface

INTRODUCTION

Knowledge management, KM, and knowledge management systems, KMS, have been topics of research for over 25 years. During this time, KM researchers have recognized the evolving nature of work and the increasingly knowledge-based society in which we live. Competitive pressures force organizations to do more with less and to leverage all they know to succeed. To meet these needs a new set of systems, called Knowledge Systems, are being developed. Knowledge systems refer to those systems that foster creativity and innovation by facilitating collaboration and knowledge capture, storage, transfer, flow, and use. Essentially knowledge systems are KMS on steroids, more than just the capture, storage, and use of knowledge. Knowledge systems researchers explore the many factors that influence the development, adoption, use, and success of knowledge systems, such as culture, measurement, governance and management, storage and communication technologies, and process modeling and development. Additional research topics include societal drivers for knowledge systems, such as an aging workforce, the need to distribute knowledge and encourage collaboration in widely dispersed organizations and societies, and competitive forces that require organizations of all types to adapt and change rapidly (Jennex & Croasdell, 2017). This preface/chapter presents the evolution of KM and KMS to knowledge systems and forms the basis for this book as this book looks at the new and advanced research being done that fuses KM/KMS, knowledge systems, and new technologies into the systems needed by organizations to meet the demands of the future.

BACKGROUND

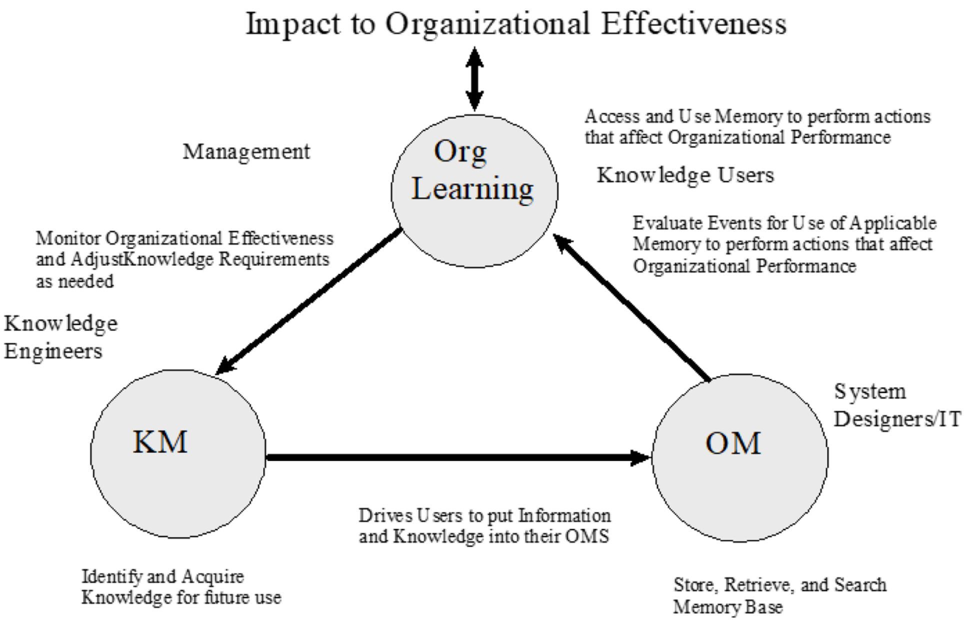
We conceptualize knowledge-based systems using a KM framework adapted to knowledge systems as we explain through the following.

Alavi and Leidner (2001, p. 114) defined a KM system (KMS) as "IT (information technology)-based systems developed to support and enhance the organizational processes of knowledge creation, storage/retrieval, transfer, and application". They observed that not all KM initiatives will implement an IT solution but that those initiatives that don't implement an IT solution will use IT as an enabler. Maier (2002) expanded on the IT concept for the KMS by calling it an information and communication technology, ICT, system that allows one to create, construct, identify, capture, acquire, select, valuate, organize, link, structure, formalize, visualize, distribute, retain, maintain, refine, evolve, access, search, and apply knowledge. Stein and Zwass (1995) defined an organizational memory information system, OMS, as the processes and IT components necessary to capture, store, and apply knowledge created in the past to current decision making. Jennex and Olfman (2006) expanded on this definition by incorporating the OMS into the KMS and adding strategy and service components to the KMS. In reviewing the literature, Barros, Ramos, and Perez (2015) viewed an OMIS as an enhancer of the OM, providing effective support and resources for the organization, assisting on decision making, in the solution of problems, as well as in quality and generation of products and services. To summarize, knowledge systems incorporate KM, OM, OL, and each of these initiatives have an information systems and technology basis; as such, a knowledge systems framework has an information systems/technology framework.

Per the above it can be seen that KM evolved from the earlier research into Organizational Memory, OM. OM evolved from the study of organizational learning, OL. As KM became the popular term to use and research, Jennex and Olfman (2002) proposed a model showing the relationship between the three disciplines. Figure 1 shows the OL-OM-KM model (Jennex and Olfman, 2002) and indicates that KM was what the organization's line organizations did to identify critical knowledge, capture it, and use it. OM is what the information systems/technology, IS/T, organization to support these activities by providing the databases, tools, and search functions to the organization. OL is what the overall organization does as knowledge is applied and put into use. Knowledge that provided a benefit results in the organization learning new ways of doing things while knowledge that had no value or actually resulted in negative value results in the organization intentionally "forgetting" how to use that knowledge (but not that it had a bad effect). In all cases OL is reflected in changes to organizational procedures, work practices, and culture.

Subsequent models have focused on adding process, strategy, and culture components to the knowledge framework. Jennex and Olfman (2003) discussed design considerations for an OMS and included technical, process, and strategy components. Jennex and Olfman (2006) included technical, process, and strategy components in adapting DeLone and McLean's (1992) IS success model into a KM

Figure 1. The KM/OM/OL Model (Jennex & Olfman, 2002)



success model. Finally, while studying KM in projects, Jennex (2003) proposed that one needs to capture culture and context to successfully use and store knowledge.

Riempp (2004) proposed an overall architecture for an integrated KMS that included all of the above components. Riempp developed the architecture for the integrated KMS by combining desk research, multiple case studies, and action research. The field research involved a KM initiative at PricewaterhouseCoopers and studies and workshops with ten organizations in the context of the customer knowledge management competence center at the University of St. Gallen (Riempp, 2004). While the literature contains more models, which we do not review as doing so falls outside our purpose here, we chose to adapt Riempp's (2004) architecture to frame KIES research into its various research areas.

Riempp's (2004) architecture for integrated KMS consists of three vertical layers (strategy, process, and system) and five horizontal pillars (knowledge transactions, content, competence, collaboration, and orientation), and the organizational culture that affects all these elements (Palte, Hertlein, Smolnik, & Riempp, 2011). In adapting Riempp's architecture, we use these components but expand on them to focus on knowledge systems. Additionally, while Riempp (2004) focuses on a KMS, we expand the architecture's applicability to knowledge systems, which includes innovation and entrepreneurship systems. We also include knowledge society systems as a subgroup of knowledge systems because these systems uniquely support public initiatives such as electronic government (e-gov), electronic health (e-health), critical infrastructure systems, and so on. Finally, we also realize that many other types of knowledge systems exist, so we do not limit knowledge systems to just these three groups. In the following paragraphs, we describe our adaptations to Riempp's (2004) KMS architecture's layers and pillars..

The strategy layer comprises the business/organization strategy, the knowledge strategy and goals, and the measurement system. Management expectation is that the business/organization and knowledge strategies are aligned; meaning that the organization has identified how and what knowledge is needed to support the latter. The measurement system identifies metrics that monitor the progress of the KM/knowledge processes (which we describe next) and links these metrics to key performance indicators (KPIs) for the business/organization strategy; the system uses both the metrics and KPIs to measure the effectiveness of knowledge use. This layer also focuses on determining, describing, and measuring knowledge system value generation.

The process layer comprises the knowledge system's business, support, and knowledge processes. These processes focus on the knowledge identification, capture, search, retrieval, modification, and application processes that specifically support the strategy layer. These processes differ from those in the pillars in that they are integrated processes that use technology, culture, context; focus on the use of knowledge in the organization; and include reporting and measurement processes.

The system layer comprises the information system/technology aspects of the knowledge system. This layer describes the specific technologies that support data acquisition and storage (such as big data, the Internet of things, cloud, KM, and social media). It also includes interface technologies such as portals, mobile devices, wearables, and visualization technologies. Additionally, it includes sensemaking technologies such as data warehouses, data mining, text mining, and Web mining. Finally, any other technologies used in knowledge systems are described.

Five functional pillars—content, collaboration, competence, orientation, and knowledge transactions—support the three knowledge system layers:

1. Content refers to the management of structured and unstructured data, information, and knowledge objects, the context of these objects, and the management of content itself with respect to lifecycle, quality, and attribution.
2. Collaboration refers to the identification, exchange, development, and use of knowledge. It also includes technologies and processes that support and manage small and large group collaboration.
3. Competence refers to the skill sets and individual and collective competencies in an organization needed to support the knowledge system.

4. Orientation refers to the vision, design, review and management processes, and blueprint/plan/standards used to architect and integrate the knowledge system.
5. Knowledge transactions refer to the interactions between the knowledge base and users. Transactions include security/protection of the actual transactions plus the design of the flow, content, format, and access requirements for the transactions.

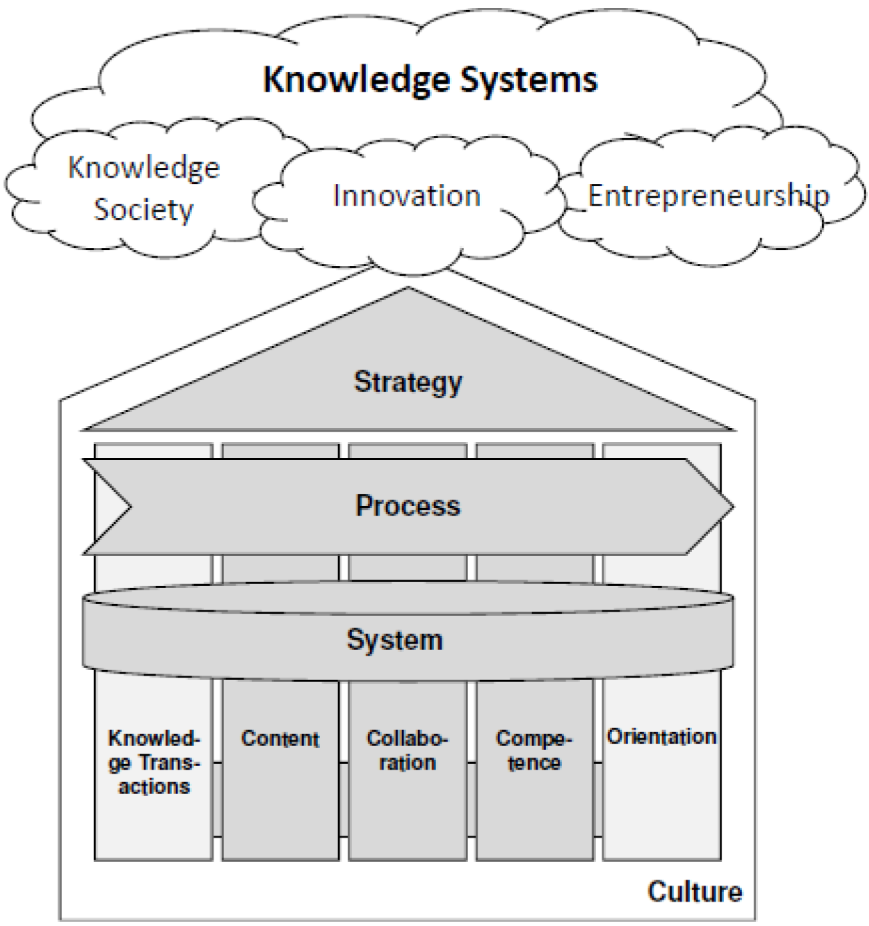
The culture layer reflects the organizational and/or national culture(s) of the users and designers of the knowledge system. The culture layer is the bottom layer because culture forms the analytical/interpretation, ethical, and application lenses that influence how the users and designers of the knowledge system view and will use the knowledge in the system. No knowledge system can succeed without incorporating understanding and applying the cultural norms of its users and designers.

FURTHER EXPANSION OF KNOWLEDGE SYSTEMS

To look at the further expansion of knowledge systems we will consider the Knowledge, Innovation, and Entrepreneurial Systems, KIES, track at the Hawaii International Conference on Systems Sciences, HICSS. Jennex et al. (2018) describes the evolution of this track and notes that it originally started as the Knowledge Management Systems track in 2005 after being a mini-track and mini-track cluster for several years. The track continued to evolve its name and scope and in 2012, the track renamed itself to the Knowledge Systems track to reflect the broader research community discussed previously. The track changed its name again in 2015 to the knowledge and innovation systems track for a similar reason. A new innovation focused mini-track was proposed and added in 2007. This mini-track did well with submissions and further publications, Gloet and Samson (2013, 2016) and several other authors wrote papers in which they linked innovation and knowledge and demonstrated them as being necessary for sustained competitive advantage. In addition, these authors presented how one can use KM in innovation management to help in managing and applying knowledge for innovation. In 2016, the track expanded once again to include work in entrepreneurship. Bandera, Bartolacci, and Passerini (2016) discussed how entrepreneurship incorporates knowledge creation and innovation in smaller organizations and the research community considered this research a sufficient constituent of knowledge and innovation systems and the track was renamed to knowledge, innovation, and entrepreneurial systems, KIES. These additions were added to the Riempp (2004) framework along with knowledge society research area nd thus creating the knowledge systems framework. Knowledge society was added as it also a knowledge focused discipline that expands knowledge systems research to include societal issues. This framework is shown in figure 2.

The KM, through the KIES track and other conferences, research community continued to grow and evolve. The research community grew by conducting research exploring the use of new technologies to support knowledge systems. The KIES and KM research community currently comprises researchers who investigate knowledge flows, knowledge economics, knowledge society and culture, knowledge system technologies, knowledge analytics, knowledge strategy, advanced knowledge systems, knowledge security, innovation, entrepreneurship, organizational learning, and crowd science. KM represents a broad and inclusive community of researchers and practitioners who have helped to evolve the inquiry and discussion related

Figure 2, Riempp's Framework Modified to Reflect Knowledge Systems (Jennex et al., 2018)

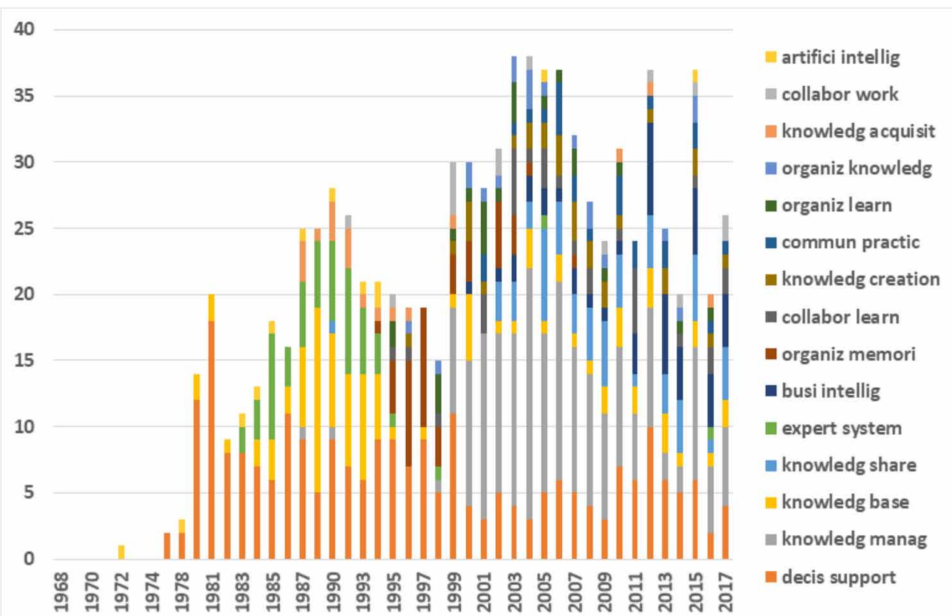


to continuing efforts to understand knowledge work and innovative systems in organizations. KM currently reflects the expanding use of knowledge work in organizations—from the development and deployment of knowledge systems that collect, store, organize, and disseminate knowledge to current applications of business intelligence, data analytics, and the Internet of things that feature more ubiquitous knowledge use. Evidence of this growth in topics is shown in Figure 3, Bigram Plot of KIES Key Terms. Figure 3 shows the transformation of key terms over the years as discussed above.

FUTURE TRENDS

How will KM evolve in the future? How will knowledge systems evolve? Figure 2 shows the architecture for knowledge systems. A new expansion is crowd science adding a twist to collaboration and decision making. Other future trends can be identified in Figure 4, the revised knowledge pyramid with the addition of big data and IoT and related technologies. See Jennex (2017) for a full discussion on the model and figure 4, highlights are discussed as follows. Figure 4 is a new interpretation on the traditional knowledge pyramid that incorporates many new technologies and initiatives into knowledge systems and shows that the traditional knowledge pyramid

Figure 3. Bigram Plot of KIES Key Terms



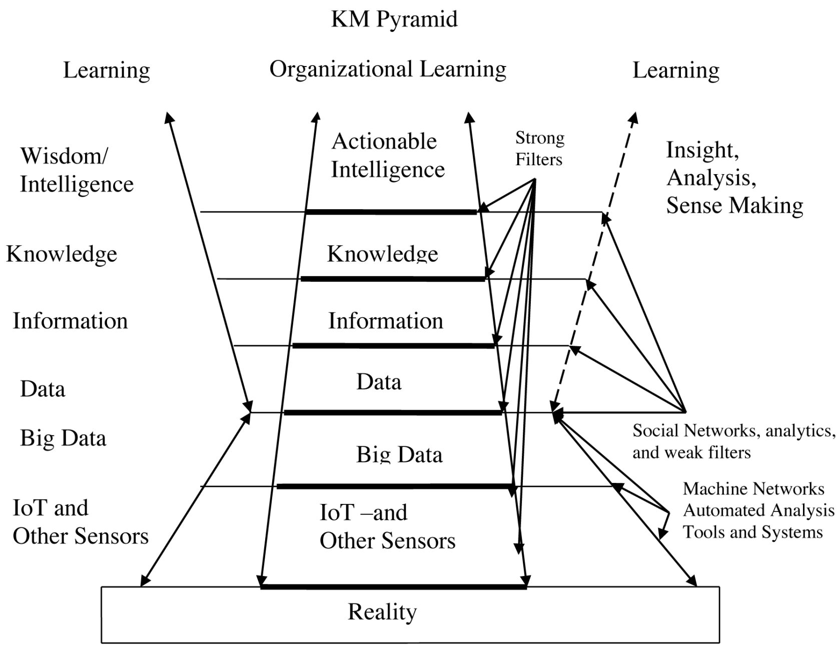
represents knowledge in action in society (and as such is called the societal knowledge pyramid) and is inverted, which implies there is more wisdom than data, why this is so is explained in Jennex (2017), it also shows that KM is still a traditional pyramid that is a subset of the societal knowledge pyramid (the KM pyramid is based on the use of organizational knowledge) that is focused on the creation of actionable intelligence. Both pyramids are framed with double-ended arrows that indicate that knowledge/data creation flows both up and down the pyramid with traditional learning processes being used to transform between layers with societal knowledge and organizational learning processes being used to transform between layers in the KM pyramid. Both learning and organizational learning rely on the use of insight, analytical, and sense making processes to guide the learning process. These insight, analytical, and sense-making processes are implemented in the form of filters to aid the transformation between layers. KM has strong filters as these filters are focused on very specific transformations that lead to actionable intelligence while societal knowledge uses weak filters, or filters based more on general understanding rather than specific transformations. Both strong and weak filters can be implemented as processes and using technologies such as machine learning, data analytics, artificial intelligence, etc. Finally, Figure 4 also integrates two newer sources of data—big data and the Internet of Things, IoT—into KM. Big data are massive databases that require automated tools to fully analyze and use their contents. IoT are smart sensors being incorporated into many aspects of business and society that generate massive amounts of data that were previously not available. Figure 4 implies that big data is a subset of IoT.

Looking at, Figure 4, we realize that KM has traditionally focused on the KM pyramid inside the overall societal knowledge pyramid resulting in Figure 4 showing two possible areas for KM expansion. The first is into knowledge society areas represented by the societal knowledge pyramid. Knowledge society systems focus on the application of societal knowledge to assist society by creating systems focused on areas such as e-health, crisis response and management, smart grid, e-learning, belief management, and wisdom systems. Wisdom and belief management systems are new approaches in the IS field and are analogous to KM systems focused on actionable intelligence. We expect that the KIES track might evolve to the knowledge, innovation, entrepreneurship, and wisdom systems (or KIEWS) track.

The second area of expansion comes from the addition of and overall impact of big data and IoT on both the societal and organizational knowledge pyramids as follows: We expect these data sources

- Autonomous knowledge generation and use that is already being seen in autonomous vehicles, smart grids, and large-scale control systems. This is expected to be a vibrant research area as researchers investigate technologies

Figure 4, The Revised Knowledge Pyramid with Big Data and IoT (Jennex, 2017)



and the ethical implications of these systems. We also expect that these systems will grow in importance to both knowledge and wisdom systems.

- Determination, construction, and implementation of filters for making massive data sets manageable. These tools are also coming into play as part of sense making and it is expected that researchers will have many design and implementation issues to address.
- Application of newer technologies such as artificial intelligence, AI, machine learning, social network analysis, text and web mining, and visual analytics to identify and capture knowledge, actionable intelligence, and wisdom. These tools are already cutting-edge technologies being applied in many disciplines. We anticipate that current knowledge/wisdom/actionable intelligence systems will incorporate these tools to create stronger, faster, and more integrated advanced knowledge/wisdom/actionable intelligence systems and that researchers will have many application areas to study and technical issues to resolve.
- New human-centered processes such as knowledge/wisdom/actionable intelligence governance, strategy, management, content management, and flow processes; as well as impacts on the valuation of knowledge/wisdom/

actionable intelligence. This These new human-centered processes will provide new research questions for many current KIES mini-tracks as well as potential new areas for new mini-tracks.

- Finally, we expect to see new methods for representing, organizing, and presenting knowledge/wisdom/ actionable intelligence to support decision making and users. We expect this to also be a vibrant research area as researchers determine how to optimize knowledge/wisdom/actionable intelligence utilization.

KM is expanding and evolving and KM research is evolving with it. New technologies and initiatives are making KM a more human and societal focused activity. This book is focused on research into these new areas and is broken into two parts. The first part is on research blending new technologies and initiatives with KM. The second part focuses on research showing application of KM blended with new technologies and initiatives.

CONCLUSION

KM has evolved into a discipline that is more than just the capture, storage, and use of knowledge based on databases and traditional ICT in organizations. It is now a discipline that incorporates structured and unstructured data as well as Big Data from IoT sources; new technologies such as AI, ML, NLP, analytics, etc are being used to identify new knowledge and to create filters for determining what is important and what is not; and finally KM is being fused with innovation entrepreneurship, and crowd science to create more powerful knowledge systems.

This book is about this evolution. The first section presents research on how KM is fusing with new initiatives and technologies. The second section presents research showing how the evolution of KM is producing new knowledge-based systems, or just knowledge systems, that can be used to address societal need and new organizational issues.

ACKNOWLEDGMENT

Parts of this preface have been presented at the 50th Hawaii International Conference on System Sciences, HICSS50, and in the Communications of the Association of Information Systems, CAIS.

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Section 1

Advanced Knowledge Management

Chapter 1
Creating Value Through Knowledge Management and Systematic Innovation Capability

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ABSTRACT

Competitive advantage in today's advanced economies is driven by innovation and the ability to manage ever-increasing forms of knowledge on a sustained basis. Knowledge-intensive industries compete primarily on their capacity to innovate and thrive on cutting-edge knowledge, which drives both research and innovation. Knowledge-intensive organizations constantly seek to reinforce sustainable links between forms of knowledge and modes of innovation. In such a dynamic environment, the proactive management of knowledge assets is essential to achieving both innovation capability and innovation performance. Since knowledge-intensive organizations play a significant role in value creation through innovation, the ways in which organizations approach knowledge management (KM) influences innovation and becomes a source of competitive advantage. As such, KM emerges as an essential management and organizational capability in the drive to create value through knowledge. This chapter explores the ways in which KM contributes to systematic innovation capability in knowledge-intensive organizations.

DOI: 10.4018/978-1-7998-2355-1.ch001

INTRODUCTION

Competitive advantage in today's advanced economies is driven by innovation and the ability to manage ever-increasing forms of knowledge on a sustained basis. Knowledge intensive industries compete primarily on their capacity to innovate and thrive on cutting-edge knowledge, which drives both research and innovation. Indeed, knowledge intensive organizations (KIOs) constantly seek to reinforce sustainable links between forms of knowledge and modes of innovation. In such a dynamic environment, the proactive management of knowledge assets is essential to achieving both innovation capability and innovation performance (Jensen et al., 2007; Kuusisto & Meyer, 2003; Miles, 2007). Since KIOs play a significant role in value creation through innovation (Muller & Doloreux, 2009; Van der Aa & Elfring, 2002), the ways in which organizations approach knowledge management (KM) influences innovation and becomes a source of competitive advantage. As such, KM emerges as an essential management and organizational capability in the drive to create value through knowledge.

Arguably, as a neutral construct, knowledge achieves consequence through human action. In this context, the human values and assumptions underpinning the learning process reveal the considerable power of not only knowledge but also the processes associated with its management (Alavi, Kayworth & Leidner, 2006; Ibrahim & Reid, 2009; Nonaka & Takeuchi, 1995). Currently, many people consider knowledge as the determining factor in economic growth (Oyelaran-Oyeyinka & Sampath, 2009). For example, Storey and Barnett (2003: 146) describe knowledge as the "key competitive sustained resource" and an organization's most important asset. Knowledge is also a primary factor of production on which competitive advantage rests (Beijers, 1995; Halawi, Aronson & McCarthy, 2005). As Davenport and Prusak (1998: 161) note, the successful management of knowledge requires a particular ''combination of human, technical and economic skills", highlighting that it is neither a haphazard nor an unmanaged process. With this growing awareness of the need to manage an organization's knowledge effectively and engender a particular arrangement of people, technology and skills, KM emerged as a distinct field of study.

Since knowledge and innovation are inextricably linked, a growing body of literature focuses on the ways in which KM can enhance and support the innovation process. However, there are challenges associated with organizational efforts to develop innovation as a core competency (Kandampully, 2002) because of the complexity of the innovation process, the diversity of knowledge assets and a broad range of approaches to KM (Malhotra & Morris, 2009). Moreover, different markets place different values on knowledge assets (Gibbons et al, 1994). This complexity combined with the interdependence that characterizes global competition compels organizations to acquire, develop and consume knowledge assets in order to achieve competitive advantage (Badaracco, 1991; Murray, 2002). Although the management of knowledge should be prioritized to the same degree as the management of an organization's human, financial and physical resources, this is not always the case. Many senior managers fail to appreciate fully the value of KM as not only a discrete management function but also a unique skill (Stewart, 1997).

This exploratory study seeks to examine the ways in which KM is manifested across a range of organizations in both the manufacturing and service sectors, with a view to determining more clearly the relationship between KM and innovation. A further objective of this study is to investigate the extent to which KM can contribute to systematic and sustained forms of innovation within organizations. A framework of Systematic Innovation Capability is then applied to organizations to determine the nature of innovation activities and practices among top innovation performers. While literature in the field has been dominated in the past by a focus on the role of innovation in the manufacturing sector, there is a growing interest in service sector innovation (Gallouj and Djellal, 2010). As such, this research investigates the relationship between KM and innovation across both the manufacturing an d service sectors and explores the likelihood that intangible assets contribute to innovation in different ways depending on the setting (Hendry et al, 2008).

This study is based on the view that without knowledge, there can be no innovation (Jorna, 2006), and is significant because it highlights the role of knowledge and its management in the innovation process. The management of knowledge may indeed hold the key to increasing systematic innovation capability in organizational contexts. The process of innovation is influenced by people's knowledge, thinking and behavior in many different ways. Given that organizations are increasingly interested in understanding how to achieve innovation capability leading to business performance, an exploration of the ways in which knowledge is managed for innovation in business settings may yield new insights.

This study may also shed light on practices that contribute to sustainable forms of innovation, rather than simply aiming for haphazard forms of innovation that lack long-term benefits and which may not be easily duplicated. The goal of sustainable innovation has human, social and management dimensions (Jorna, 2006), and today's KIOs face significant challenges on all these levels in order to gain and maintain competitive advantage. For managers, this involves developing new forms of knowledge, embedding this new knowledge within organizations, as well as managing flows of information, knowledge and experience. It also involves the strategic development of knowledge relationships to ensure a broad range of knowledge sources and effective means of knowledge exchange.

LITERATURE REVIEW

Since 2000, a growing body of research and practitioner driven material on KM has penetrated the literature. In this period, diversity, specialized discourses, variations in approaches to KM and appropriate research methodologies characterize these contributions. However, as a discrete field of study, KM remains an emerging area (Heisig, 2009). As such, this growing body of literature is frequently "unconnected", due to a lack of association between ideas and more integrated approaches to the topic. Diversity in the field of KM also encouraged several debates or 'turf wars' with numerous interest groups staking their claims to various principles and practices of KM. For some people, KM is a means to make IT more efficient; for others, the focus is on developing effective ways of managing human resources (HR). Others see KM as a crucial part of records management or library and information management. Particularly in the administrative sciences, writers consider the discovery and creation of new knowledge to be at the core of effective KM.

KM is a complex and subjective endeavor that is highly contextualized and therefore highly interpretive in nature. The KM literature can be classified as belonging to various broad paradigm orientations, each representing basic theoretical assumptions, biases, beliefs and frameworks that underpin KM practices (Gloet & Berrell; Gloet & Samson, 2012). Previous research has identified three main paradigm orientations that encapsulate the basic theoretical assumptions and biases underpinning KM practices. The classification of these paradigms is based on whether KM is driven by IT, humanist or organizational culture elements. An IT orientation positions technology as the anchor for developing approaches to KM. A humanist orientation focuses on the contribution of people to KM, whereas an organizational culture approach takes a resource based view where knowledge is regarded as a strategic resource. These three basic orientations can be identified in various organizational contexts and because each orientation involves very different approaches to KM, the tools and methodologies used to develop and sustain KM differ within and across organizations.

In the absence of any universally accepted definition of KM, it is not surprising that multiple definitions and understandings would emerge (Wallace, 2007), especially given that precise definitions of 'knowledge' and 'management' are also elusive. Indeed, linking the terms to form knowledge management', the task becomes even more challenging. The Australian KM Standard (Standards Australia, 2005:8) offers managers a functional definition of KM as a cross-disciplinary construct, which involves "the design, implementation and review of social and technological activities and processes to improve the creating, sharing, and applying or using of knowledge". In this light, KM links to "innovation and sharing behaviors" and "managing complexity and ambiguity through knowledge networks and connections".

Investigating smart processes and implementing "people-centric technologies" are part of an environment where the central role of knowledge in securing and maintaining competitive advantage emerges as a constant theme (Bessant & Venables, 2008; Laperche & Uzunidis, 2008; Quinn, 1992; Quintas et al., 1997). The need for effective and strategic KM in organizations is also emphasized (Farzin et al., 2014; Yang, 2010; Wu & Lin, 2009).

The literature also abounds with definitions of innovation, although common threads emerge. Drucker (1985) for example, views innovation as a process that exploits change through specific and disciplined practices that are underpinned by learning. Generally, in an organizational context, innovation implies outcomes such as improving performance, enhancing problem-solving capabilities, adding value and creating competitive advantage. Afuah (2003) describes innovations as the use of new knowledge to offer a new product, service or process of invention along with commercialization. Therefore, the innovation process implies discovery, application and outcome. Tidd and Bessant (2014:3), provide a succinct definition of innovation as "the process of creating value from ideas". Thus, innovation *per se* is predominantly about change, and of translating knowledge into value creation.

In terms of the links between KM and innovation, multiple perspectives and a lack of rigorous empirical research pose significant challenges for those seeking definitive answers. Nevertheless, the literature reveals that successful KM approaches in innovation have common factors. In an investigation of the relationship between KM, levels of innovation and levels of competitiveness in organizations, Carneiro (2000) highlights the strategic nature of knowledge development. He suggests that a strategic approach to KM positively influences innovation and competitiveness in organizations. Keupp et al. (2010) note the value of KM in shaping and supporting innovation strategies, particularly in times of changing circumstances in both the internal and external environment. Darroch (2005) also emphasizes the strategic potential of successful KM as a coordinating mechanism to enhance and support both innovation and business performance.

Du Plessis (2007) views KM as critical because innovation is highly dependent on managing knowledge in ways that align knowledge to the innovation process. Her research identifies three significant drivers of KM in innovation. First, this involves creating and sustaining competitive advantage through the utilization of knowledge collaboration processes. A second driver involves the capacity of an organization to reduce complexity in the innovation process by managing knowledge as a strategic resource. Finally, KM can drive innovation through the process of integrating internal and external knowledge sources, thus making knowledge for innovation more accessible. For Simpson (2002), a strategic approach to KM requires organizations to hone continuously their technological, organizational and managerial processes to secure positive strategic positions that support innovation.

Other KM approaches linked to innovation success include a strong IT infrastructure within the organization (Ahmad & Schroeder, 2011) and embedding understandings about innovation deeply within an organization's culture (Donate & Guadamillas, 2010). Through collaboration and engagement with customers, KM can enhance innovation opportunities (Sawhney et al, 2005), as well as through engaging with lead users (Mahr & Lievens, 2012). Other research points to the role of KM in supporting various forms of open innovation (Chiaroni et al, 2011) and in increasing the absorptive capacity of organizations (Spithoven et al, 2011). KM can also contribute to change management and risk reduction processes in organizations and can support knowledge-based risk management frameworks that improve the success of technology-based innovations (Mu et al, 2009). The above approaches signal the importance of KM in mediating and monitoring the contextual aspects of the innovation process.

A number of studies refer to the relationship between KM and HRM in supporting innovation, including developing employee capabilities for innovation (Kong et al, 2011; Lengnick-Hall & Lengnick-Hall, 2003), enhancing organizational learning (Jimenez-Jimenez & Saint-Valle, 2011) and rewarding employees for knowledge acquisition and sharing (Jaw et al., 2010; Foss et. al., 2011). Indeed, KM has been viewed as a mediator between HRM and innovation (Lopez-Cabrales et al., 2009; Chen & Huang, 2009). Through a focus on knowledge and learning, KM can contribute to innovation and sustainability of operations and information systems (Gavronski et al., 2012). Liao and Wu's (2010) research found that by using organizational learning as a mediator, KM can improve organizational innovation. Knowledge collaboration and learning also supports innovation across a variety of platforms (Quist & Tukker, 2013).

KM supports the management of innovation processes through the systematic acquisition, sharing and dissemination of knowledge (Darroch, 2005; McAdam, 2000), as well as through managing inputs to decision making processes (Van Riel et al., 2004). In contributing to the development of a knowledge based organizational culture, KM has been found to support organizational innovation and technological performance (Donate & Guadamillas, 2010). When KM contributes to a knowledge focused culture that is underpinned by strong communication channels (Sanz-Valle et al., 2011; Foss et al., 2011), innovation performance is enhanced. Researchers also emphasize the pivotal role of KM in engendering internal work environments that support creativity and foster innovation (Zheng et al, 2010). KM plays an important role in knowledge capture to support innovation (Dougherty, 2004), including sophisticated methods of environmental scanning (Cousins et al., 2011). KM can also facilitate inter-organizational knowledge flows (Chiang & Hung, 2010), as well as increase innovation capacity by broadening knowledge sources and linking knowledge and technology more effectively (Leiponen & Helfat, 2010).

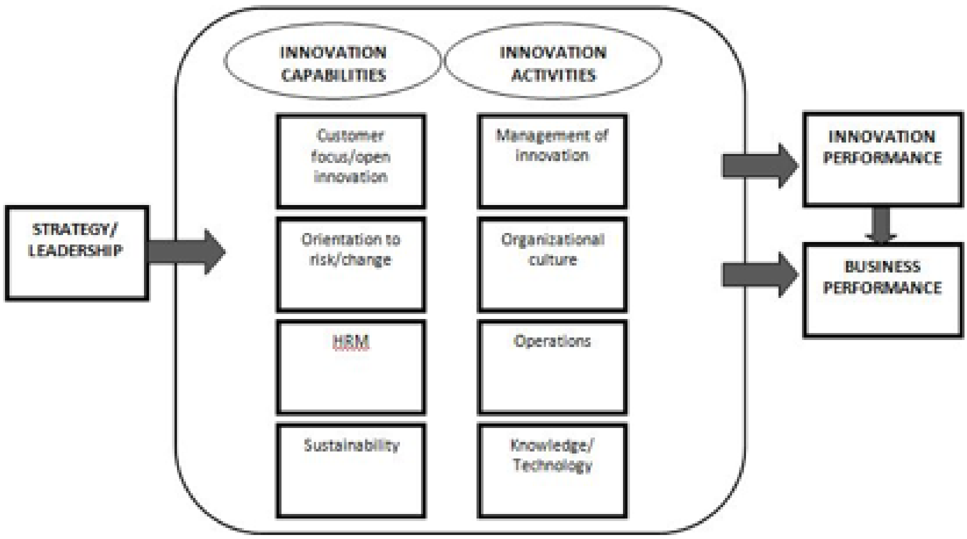
While innovation is actively pursued across both manufacturing and service sector organizations, Lyons et al. (2007) suggest that each sector requires a different approach in order for innovation to be successful. They argue that in services, innovation efforts must permeate the organizational structure and culture in order to be successful. Emerging from the new focus on innovation in the service sector in the mid-2000s was a realization that the uniqueness of the sector required different notions about innovation than those previously applied to the manufacturing sector (Hipp & Grupp, 2005). In this light, innovation in business services presents specific challenges, which include "conceptualizing and defining innovation" and furthermore, identifying where innovation occurs within a business. Kandampully (2002) suggests that the utility of innovation *per se* in customer driven settings is its role in creating competitive advantage. Therefore, the targets for knowledge assets are customers; while technology facilitates the process, knowledge is the essential element. He therefore argues that the core competency of a service organization should be innovation. Service organizations also require less formalized approaches to innovation for successful outcomes compared to manufacturing settings (Hendry et al., 2008). In manufacturing, innovation is often a more structured, rigid and standardized process (Ettlie & Rosenthal, 2011). In light of the discussion above, the potential of studies that investigate the relationship between KM and innovation across both manufacturing and service sector organizations is considerable.

Systematic Innovation Capability Model

This study is framed by a model of Systematic Innovation Capability (see Figure 1). Based on previous research (Samson, 2010; Gloet & Samson, 2013), the Strategic Innovation Capability model identifies the processes and relationships used by successful organizations to generate a series of innovations that create value and deliver business success. The building blocks of the model are wide-ranging but include aspects of strategy, leadership, customer focus, HRM, organizational culture and approaches to sustainability. Other aspects include operations and the management of innovation, knowledge and technology. The development of systematic innovation capability requires a holistic and integrated approach to innovation across all of the above attributes.

As such, systematic innovation capability is best achieved when all of the above 'building blocks' are present. By incorporating both innovation performance and business performance as essential elements, the model views innovation from a value creation perspective, where systematic innovation capability leads to a continuous stream of innovation, rather than haphazard or unplanned innovation. A focus on innovation performance and business results also assumes that resources are committed towards achieving innovation, and that aspects of innovation performance

Figure 1. Systematic innovation capability model



are measured on an ongoing basis. While recognizing that significant challenges accompany innovation, the framework assumes that those organizations with a robust and systematic innovation capability have higher probabilities of success with either large scale or incremental innovation.

Initial Study: Case Study Research

The first part of the study used data derived from 16 Australian manufacturing and service organizations to investigate the relationship between KM, systematic innovation and innovation effectiveness. Following the initial study, a large-scale survey of over 2,400 Australian managers was undertaken to investigate the extent of systematic innovation capability within their organizations. For the initial study, the following research questions (RQs) framed the work:

RQ1. What is the nature of the relationship between KM and innovation?
RQ2. What is the extent of the contribution of KM to systematic innovation capability?

Given that both KM and innovation represent multiple perspectives and contexts, a case study approach was applied to this research. Case study approaches are well suited to research environments characterized by complexity and overlapping approaches and scenarios (Yin, 2014), such as is the case with KM and innovation. In order to ensure methodological soundness, case studies should be based on careful selection of appropriate cases, in addition to the scientific application of case study principles and practices. Given that 16 organizations were investigated in this study, a ''cross-case analysis'' was employed to ensure a strong replication logic underpinning the cases and hence increasing construct validity, reliability and generalizability of the findings (Miles and Huberman, 1994).

A purposive sampling methodology (Recker, 2013) also enhanced reliability of the cases selected (Yin, 2014). Case study organizations demonstrated robust forms of KM where KM initiatives were planned, embedded and well resourced. Moreover, each of the selected case study organizations demonstrated their capacity for innovation across a range of indicators of innovation performance. Construct validity in multiple case studies is essential (Yin, 2014). The constructs employed here are similar to validated constructs in previous research (Samson, 2010; Gloet & Samson, 2012). Moreover, making generalizations based on statistical analysis is not the goal of this study – as Merriam (1998) suggests, "probabilistic sampling is not necessary or even justifiable'' in research of the type undertaken here. The sample also offered the researchers variance across company size, ownership type and industry sector and included foreign-owned and local organizations. The organizations consisted of seven manufacturing organizations (M1-7), seven in the services sector (S1-7) and two with a product/services mix (P1-2). It was anticipated that this range of organizations would yield insights into differences in approaches to KM and innovation across sectors, business types and organizational size. Table 1 displays the business type of each organization.

The study followed the case study protocols recommended by Yin (2014), which included using stem questions to guide participant discussion during the interviews and align the discussion to the research questions. Stem questions established the basis for analyzing systematic innovation and KM in the case organizations. Responses gave clues to organizations' approaches to both systematic innovation and KM. The stem questions are set out below:

§ How is KM manifested in your organization?
§ How is the relationship between KM and innovation viewed?
§ What was the basis for introducing KM into your organization?
§ How did your organization implement KM?
§ How does KM contribute to innovation in your organization?
§ What difficulties were encountered and how were these addressed?
§ What type of lessons have been learned to date?
§ What types of benefits have been achieved?
§ What would you like to see in future iterations of KM to support innovation?

Table 1. Business type across case study organizations

Code	Business Type
M1	Bakery products
M2	Differentiated supply chain solutions/product design
M3	Technology, mining and related products
M4	Design and production of specialty fabrics
M5	Textile inserts – product manufacturing
M6	Production of high performance textiles
M7	Automobile production
PS1	Mobile phone products and services
PS2	Travel support products and services
S1	Customized IT solutions and product development
S2	Ambulance services/community support
S3	Real estate services
S4	Environmental monitoring
S5	Revenue collection
S6	Legal services
S7	City council services and support

Depending on the size and scope of the organization, between two and six managers were interviewed in each case study organization. The multiple perspectives gleaned from the respondents essentially revealed the organization's dominant orientation to KM, as well as insights into various KM practices that support innovation. Textual analysis was applied to interpret the data gathered during the in-depth interviews, and a coding system allowed the researchers to place data in one or more predetermined categories. The data was grouped according to emerging common patterns or themes. The researchers also noted when a participant departed from the dominant pattern of responses and sought clarifications. The influence of the organizational environment helped explain divergent responses. A more comprehensive rationalization of discrepancies occurred when patterns of responses diverged significantly from previous research. In each case, a range of documentation supported the analysis, including Annual Reports, Business Reports, performance data, project proposals and progress reports. Material available in the public domain, including the organizations' websites or via domains maintained by state and/or federal government departments also enriched the study.

Findings From the Initial Study

The organizations in this study invested considerable resources and significant thought into supporting KM. As such, KM was a conscious and deliberate undertaking, rather than being arbitrary or haphazard. However, each of the case study organizations faced different challenges in implementing KM to support innovation. While acknowledging the importance of people to the process of KM, organizations tended to identify more strongly with IT-based forms of KM. A predominant IT orientation to KM meant that most managers were more comfortable in dealing with explicit, rather than tacit forms of knowledge. All managers in the study recognized the importance of organizational contexts in supporting KM initiatives, such as developing a strategy for KM, ensuring leadership support and shaping an organisational culture that supports KM. At the same time, the significant challenges associated with people-focused approaches to KM were clearly highlighted by the same managers.

While there are no agreed guidelines or recipes for success in creating an innovation-driven organization, the role of KM was widely regarded as being integral to the innovation process. As such, the participants, all of whom held management positions, reported practical understandings about how KM contributed to innovation across a range of activities. This includes systematically gathering, managing and disseminating information, as well as providing strong support across various business processes. KM also contributed to quality and continuous improvement, as well as shaping learning and organizational development initiatives. Managers reported that strategic KM encouraged and supported clear communication processes, and assisted in growing a collaborative work environment. Through these contributions, KM emerged as a main driver of innovation that supports sustained competitive advantage.

All managers, whether in organizations with a manufacturing, services or a product/services orientation, advocated the need for a strategic thrust to drive both KM and innovation. Many advocated the need for leadership, both from the top but also from middle management in order to grow and sustain KM practices that support innovation. Regardless of their sector location, the case study organizations demonstrated a very strong customer focus, and managers regarded customers as a major source of knowledge to inform and drive innovation. The proactive management of innovation activities, along with monitoring and measurement across a range of performance indicators, were found to be essential for developing sustained forms of innovation within these organizations. Managers also identified a number of major enablers of KM to support innovation across their respective organizations. These included formal and informal KM practices, coupled with a solid IT infrastructure and centralized access to information across the organization, including repositories and intranets. A variety of channels and means by which to share knowledge were

Table 2. Major enablers of KM to support innovation

• Formal and informal KM practices within the organization
• A solid IT infrastructure
• Centralized access to information across the organization including repositories and intranets
• A variety of channels and means by which to share knowledge
• The use of teams and group structures to communicate and collaborate
• Effective learning programs to support innovation
• A philosophy of quality and a commitment to continuous improvement
• Recognition and rewards for contributions to KM and innovation

also useful, as well as the use of teams and group structures to communicate and collaborate. KM can also act as a major enabler of systematic innovation through organizational development and learning programs. A philosophy of quality and a commitment to continuous improvement across the organization assists KM to support incremental forms of innovation. Finally, employee recognition and rewards for contributions to KM and innovation assist in employee engagement and motivation, thus driving increased innovation efforts. These major enablers of KM to support innovation are listed in Table 2.

The scope and nature of KM and innovation within the case study organizations is revealed using the Systematic Innovation Capability framework that outlines the main attributes of systematic innovation capability (see Figure 1). Managers identified nine areas where their organizations rated highly on systematic innovation capability. The highest rankings came from the following areas:

- Leadership
- Customer Focus
- Strategy
- Quality processes and philosophy
- Values and culture to support innovation
- External partners/open innovation
- Change Focus
- Learning
- HR orientation to innovation

By way of contrast, areas where systematic innovation capability did not rate highly within the case study organizations include:

- Developing an appetite for risk
- Building and sustaining knowledge relationships
- Resources commitment for innovation

- Measurement of innovation

DISCUSSION

The literature on the relationship between KM and innovation highlights the complex and multidimensional nature of both areas, characterized by multiple perspectives and differing views regarding KM and innovation. The managers in all of the case study organizations reflected these multiple views. In some organizations, KM practices were dominated by IT, while others took a more people-oriented approach to KM. In other cases, KM reflected a strategic resource based view where knowledge was regarded as a strategic resource to be managed. With respect to innovation, some organizations were more focused on research and development or developing new technologies and services, while others regarded innovation as a series of incremental or process improvements. Managers generally recognized the potential of KM to contribute to innovation, but most found it difficult to articulate the precise nature of this link, even within their own organizations. Organizations appeared to lack common definitions or understandings with respect to KM, which also extended to a lack of common articulations about innovation. The multi-dimensional and contextual nature of both innovation and KM might explain this shortcoming.

Managers generally agreed that KM approaches focused on people and organizational culture are more important when managing tacit forms of knowledge, although many pointed to the greater challenges associated with these approaches. However, the same managers remained ambiguous and somewhat uncomfortable about tacit knowledge, reporting greater feelings of confidence and success when they worked with technology-based, IT-driven KM initiatives. While managers were emphatic that the people and organizational culture aspects of KM are most important in supporting innovation, they were far more comfortable dealing with explicit rather than tacit forms of knowledge, so preferences for IT-driven approaches subtly held sway in the discussions.

Managers also identified a number of areas where KM supports innovation, including strategy, leadership, HRM, learning, IT and organizational culture. Many of these areas have also been identifed in the literature. Embedding KM and innovation at the strategic level, which reinforces the pivotal role of leadership and management to support innovation, is a strong theme in the literature (Miles, 2007; Makri and Scandura, 2010). Managers spoke of the need to link KM and systematic innovation to the overall business strategy by aligning KM and innovation strategies with their organization's mission and business objectives. Such a linkage demonstrates a strong organizational commitment to both KM and innovation initiatives, and when given a strategic foothold, KM and innovation were less inclined to be treated as just another passing fad. However, managers suggested that even though a KM strategy provides direction and support for KM activities, the managers suggested that a KM strategy alone is not enough to achieve significant inroads into sustained innovation. For sustained and systematic forms of innovation to become embedded, an innovation strategy based on the overall business strategy is also required.

While managers implicitly favored IT approaches to KM and innovation, the same managers saw that developing links between KM and HRM helped address the challenges posed by managing people and organizational culture aspects related to innovation. Such linkages include the development of performance management systems that recognize and reward knowledge work leading to innovation, as well as the implementation of sophisticated HRD programs designed to increase employee engagement, develop skills and enhance capabilities that add value to an organization; these developments are also mirrored in the literature (Butler and Grace, 2010; Kong et al., 2011). Managers also reported that KM supported a strong customer focus, based on open innovation and adopting lead user strategies, thereby facilitating communication and collaboration with customers (Sawhney et al., 2005).

Despite demonstrating multiple perspectives on KM and Innovation, managers alluded to the importance of communicating clearly about KM and innovation, developing a culture underpinned by common values, goals and objectives through a shared language (Cano and Cano, 2006; Fugate et al., 2009; Befecki et al., 2009). Developing a learning culture focused on innovation was also considered to be a fundamental component in maintaining competitive advantage. By shaping a learning culture where innovation is considered a a core value, KM can support the processes of knowledge generation, sharing and dissemination, all of which are fundamental to innovation.

While responses from managers in the case studies yielded some insights into the role of KM in supporting innovation generally, the salient connections between KM and systematic innovation capability are far more tenuous. The case studies clearly revealed a lack of KM support for particular innovation activities, including the commitment of resources for innovation, balancing large scale and incremental forms of innovation, developing an appetite for risk and measuring innovation. One of the main challenges faced by the organizations is the lack of resourcing for both KM and innovation. The literature indicates that investment in these areas is essential for sustained innovation performance and overall business success (Hendry et al., 2008). Perhaps most surprisingly, KM did not appear to support the development and nurturing of knowledge relationships, either with customers, suppliers or other sources, which are fundamental to systematic and sustainable forms of innovation.

In all the case study organizations, there was significant investment in technological infrastructure and significant investment in IT to support KM. However, investments in other attributes of KM and systematic innovation capability, such as HR, culture and knowledge relationships were not apparent. Another major challenge involved the development of a different attitude to risk management by recognizing that successful innovation efforts often depend on risk-taking in order to come to fruition (Befecki et al, 2009). In three of the case studies, managers reported that KM was instrumental in mitigating risk rather than encouraging an appetite for risk. The measurement of both KM and innovation was also shown to be a major shortcoming among the case study organizations, mirroring a general deficiency alluded to in the literature (Hipp and Grupp, 2005).

There were more instances where innovation focused on incremental and small-scale improvement rather than on large-scale radical transformation. This is not surprising given that all organizations were committed to pursuing quality initiatives within a strong culture of continuous improvement, which permeated each organization's unique culture. Moreover, two of the service sector case studies were in the government sector, where the main drivers of KM were continuous improvement and business excellence rather than seeking competitive advantage and creating value from innovation.

Some significant differences were noted between service and manufacturing sector organizations. On the whole, manufacturing organizations seemed to be outperforming service sector organizations or those with a product/services mix on systematic innovation capability. Two of the service sector case studies were government organizations, although this factor does not fully account for the differences. Processes and approaches supporting innovation tended to be more formal in the manufacturing sector. Moreover, manufacturing companies tended to take a more disciplined approach to innovation compared to service sector organizations, perhaps due to the tangible outcomes of manufacturing. Hence, manufacturing organizations displayed a more disciplined style of innovation. Service sector organizations favored organic approaches to the innovation process.

Even though service sector organizations are characterized by higher levels of direct interaction with customers, all organizations in the study rated highly on customer focus. What was also surprising, given that innovation in services is closely tied to customers, the service sector organizations in this study rated poorly on open innovation and development of knowledge relationships, which are a source of knowledge and hence innovation. Service sector organizations were less inclined than other organizations to measure innovation efforts. This may be due to the higher levels of direct customer interaction in services and the fact that these organizations deal more heavily in intangible forms of knowledge than manufacturing firms. The service sector organizations rated poorly in developing a strategy focus. Most did not proactively manage their innovation processes, perhaps because the nature of these processes in the services sector are more fluid.

While organizational size did not turn out to be a significant differentiator in this study, the researchers noted some differences between large and small organizations. Smaller organizations lacked maturity in systematic innovation because the process often relied on one person or a small group, thereby concentrating the risk elements attached to the process. In comparison, larger organizations were more deeply resourced and systematized, less vulnerable to a change, with the risk spread across many people and teams, thereby reducing the risks associated with innovation. However, given that all organizations generally rated poorly on developing an appetite for risk, this issue warrants further investigation.

SECOND STAGE OF THE RESEARCH: LARGE SCALE SURVEY

In order to test some of the findings from the case studies, we were interested in the extent to which some of the insights gained from the case studies could be generalized across a broader range of organizations. Following the initial case study research, a large-scale national survey was undertaken to examine the nature and extent of systematic innovation capability in Australian organizations, and sought to address the following questions:

- What business strategies do innovative organizations formulate and implement, and how do they go about this?
- How do innovative organizations manage their knowledge?
- How do these organizations resource their innovation capabilities and activities?
- How do innovation leaders measure their innovation success?
- How do innovation leaders reward, recognize and promote staff?
- How do these innovative organizations drive culture and behaviors towards innovation?
- In what ways and to what extent is sustainable development being applied and used in innovation-oriented companies?
- Who in these organizations are the critical contributors and catalysts of innovation?
- What are the characteristics of and differences between organizations that are innovation ‘leaders’ (top 25% innovation performers) and those that are innovation ‘laggers’ (bottom 25%)?

The comprehensive online survey was launched by the Australian Institute of Management (AIM) in October 2012, and AIM members across Australia were invited to participate in the survey.

Innovation is a key topic of public and professional interest in Australia. Given that Australia faces challenges in achieving and maintaining global competitiveness in terms of cost, service and quality, developing systematic innovation capability is vital to meeting these challenges. The aim of the survey was to test the strength of connection between innovation leadership and board practices, innovation strategies, innovation practices, resources and activities, innovation measures and business outcomes. The survey took an average of 30 minutes to complete fully. A total of 2,499 AIM members attempted the survey, 2,025 substantially completed the survey and 1,579 completed the survey in its entirety. Data was analyzed using descriptive statistics and techniques of association, factor analysis, correlation, regression, structural equation modelling, and related methods.

The survey captured substantive data relating to innovation capability, innovation activities and innovation performance. Key findings from the survey were:

- Innovation is increasingly seen as a means of achieving competitive advantage. Managing knowledge and innovation effectively is key to achieving competitive advantage.
- Sustainable and systematic innovation requires a holistic approach across a range of innovation activities in order to maximize innovation performance, from leadership through innovation, strategy and process management.
- The research identified certain innovation practices that were significant predictors of innovation performance that can assist organizations to achieve systematic innovation capability. These were factors associated with high innovation performance, across industries and organizations of all sizes and structures.
- Significant differences were noted between the top quartile (top 25%) and bottom quartile (bottom 25%) of innovation performers in Australia. These differences include the priorities given to innovation in business strategy, leadership factors, resourcing of innovation, measurement and cultural factors (Samson and Gloet, 2012).

Indeed, the most interesting results gleaned from the survey concerned the activities and practices of those organizations identified as the top quartile innovation performers. Measuring innovation takes many forms and can involve assessing diverse areas such as innovation strategy, capability development, processes, people and culture. A major aim of this survey was to determine the nature and extent of strategic innovation capability that leads to innovation performance, and ultimately to business performance. As a consequence, we adopted a range of measures to assess innovation performance, as well as a separate set of measures designed to evaluate business performance.

Innovation performance was measured across the following indicators:

- Return on innovation spending
- New product/services success ratio
- Responsiveness to the market
- Number of new products and/or services
- Enhancing existing products and/or services
- Revenue arising specifically from new products and/or services
- Level of employee engagement
- Cost reductions
- Number of patents secured.

Business performance was measured across the following indicators:

- Revenue growth
- Cash flow
- Differentiation of products and/or services
- Profitability
- Long-term competitive advantage
- Productivity
- Customer satisfaction
- Cost advantages.

These indicators are based on generally recognized and accepted measures found in the business and innovation literature, and which have been validated through previous case studies and surveys (Gloet and Samson, 2012). While business performance is heavily dominated by profit drivers such as revenue growth, cash flow and profitability, innovation performance measures have a broader focus and include such dimensions as product and/or service development, employee engagement and responsiveness to or leadership of the market. Survey respondents were asked to provide feedback on a number of items that related to each of the innovation building blocks that make up the Strategic Innovation Capability Model (see Figure 1). This feedback provided insights into various aspects of innovation capability and innovation activities of Australian organizations.

Results showed there were significant differences between innovation leaders (the top 25% of innovation performers) versus innovation 'laggers' (the bottom 25%) across various aspects of innovation capability, activities and performance. For instance, innovation leaders are almost twice as likely to assign responsibility for innovation to an individual or group than are innovation laggers. This indicates that innovation performance is driven more strategically when explicit responsibility is assigned for innovation. Assigning responsibility for innovation also leads to a high likelihood that there is a strategy in place regarding innovation within the organization. The study also revealed that innovation leaders invest far more heavily in R&D as well as new technology and equipment.

Innovation leaders are more than twice as likely to be making innovation a high priority in their business strategy, as well as encouraging support for innovation at senior leadership levels. Leaders also encourage managers to get involved in innovation projects and to act as role models for innovative behaviors. Innovation leaders generally focus strongly on obtaining customer inputs, feedback, ideas and on creating value for the customer. On the other hand, laggers do not demonstrate a commitment to seeking customer feedback or on value creation geared toward customers. Innovation leaders also engage more heavily in various forms of open collaboration, such as collaborating with outside partners to develop new products and/or services. Open innovation also includes working closely with external parties, such as lead users, who can provide input and feedback at various stages of product/service development and implementation. Further, leaders more consistently engaged in various forms of open innovation to a greater extent than laggers. This highlights the significance of a strong customer orientation to innovation success.

Innovation is clearly about change, whether it is introduction of new goods/services, processes or changes to business structures. Leaders in innovation are certainly more open to change, and they indicated on average a more enlightened approach to taking calculated risks. Innovation leaders were much more likely to have a strategy for managing risk. It would appear that planning for change and developing a strategic approach to risk management means that leader organizations have more information at hand to make decisions when it comes to assessing potential risk versus potential value of innovation projects. There was also a clear difference between leaders and laggers on the extent of teamwork, with leaders far more likely to structure innovation work in teams. Utilizing team structures for innovation projects enhances collaboration, brings cross-functional expertise to bear, and drives forward the confidence and sense of collective ownership of innovation ideas as they traverse the challenging road towards commercialization. We also note that the professional practice of measuring (and hence likely managing) of employee satisfaction was more frequent in Innovation leaders. Effective knowledge management was a key aspect of innovation leader organizations.

Innovation leaders placed greater importance on all aspects of the human resource cycle, from selection, through training and capabilities development, as well as stronger approaches to recognition and rewards for innovation. This implies that Innovation leaders practice a more strategic form of Human Resource Management than Innovation laggers. This involves developing an HRM strategy closely linked to the overall business strategy as well as to the innovation strategy of the organization. In leader organizations, articulating desirable employee capabilities linked to innovation guided the recruitment and selection process in order to identify the candidates with the best 'fit' for an innovative organization. Training and development initiatives further developed capabilities and skills related to innovation. Performance appraisal systems in leader organizations included measures of employee contributions to innovation, which were tied to remuneration and rewards.

Innovation leaders were significantly more engaged in all aspects of sustainable development, than laggers. Overall, leaders were far more engaged not only in measuring their social and environmental impacts, but also working proactively to improve on these measures. This may have to do with the notion that just as being an Innovation leader requires strong proactive leadership and a desire to be out front in your industry, and so do activities that pertain to sustainable development – and these need to be measured. In terms of organizational culture, innovation leaders reported significantly more frequent employee activities related to innovation, and that their firms gave more time for employees to converse in informal ways. They also reported higher skill levels among employees. It is likely that in laggers, employees are working under short term pressures such that there is less time for idea creation, discussion and teamwork related to innovation projects, and lower levels of the skills necessary to contribute to those innovations.

Innovation leaders also demonstrated higher performance overall in terms of innovation and process management, particularly in the areas of knowledge management and technology management. Well defined knowledge resources and processes, coupled with sufficient investment in technology to support innovation, was associated with increased levels of innovation performance. Both innovation leaders and laggers reported that they benchmarked competitors, but more Innovation leaders did so. Innovation leaders also were almost twice as likely to report that there was a strong alignment between the organization's business strategy and technology capabilities.

Business Performance Predictors

Following further analysis of the data, the most significant predictors of business performance were identified across each of the building blocks of innovation. The results are displayed in Table 3 below:

Table 3 can be used by managers as a guide to 'best practices' in pursuing systematic innovation capability and performance. The elements of Table 3 are significantly related to higher levels of such performance.

Table 3. Predictors of innovation performance

BUILDING BLOCKS OF INNOVATION	TOP PREDICTORS OF BUSINESS PERFORMANCE
Strategy & Leadership	1. Managers get involved in innovation projects 2. Innovation is prioritized in the business strategy 3. Decision making is decentralized
Customer Focus & Open Innovation	1. Ideas come from external sources such as lead users 2. Developing and creating new value is a priority 3. Collaboration with outside partners
Orientation to Risk & Change	1. The organization is willing to take calculated risks 2. Changes are implemented effectively 3. Project management of innovation activities 4. The organization has a strategy for managing risk
Human Resource Management	1. Clearly articulated employee capabilities relate to innovation 2. Teamwork is emphasized 3. Employees are rewarded financially for innovation contributions
Sustainability	1. Working proactively to improve social and community impact of the business
Management of Innovation Processes	1. Balancing a portfolio pipeline of innovations 2. Assessing risk versus potential value of projects 3. Idea generation
Culture & Communications	1. Ample opportunity for informal conversations among employees 2. Employees strive to improve org processes 3. Innovation is an embedded part of daily work
Operations & Partnerships	1. Benchmarking competitors 2. Business strategy and technology strongly aligned 3. Sufficient investment in technology and infrastructure
Knowledge & Technology	1. Customers' technological knowledge is valuable 2. Rapid response to technological changes in the industry 3. Ability to obtain knowledge from suppliers

CONCLUSION

Findings from both the case study research and the large scale survey suggest a strong link between KM and innovation. However, the ways in which KM contributes to systematic innovation capability is less than clear. The close relationship between knowledge and innovation is highlighted particularly by the ways in which top innovation organizations manage their knowledge across the building blocks of systematic innovation capability. It is abundantly clear that the effective management of knowledge is a fundamental characteristic of innovation leader organizations, thus contributing to innovation performance and business performance and leading to sustained forms of competitive advantage.

However, further research on the nature of the relationship between KM and systematic innovation capability is warranted. This research was exploratory in nature and limited to the Australian context – future research could broaden the selection of organizations; thus, a larger sample across other countries may generate deeper insights regarding the nature of KM and innovation management in different contexts. As the links between KM, innovation in general and systematic innovation capability in particular represent complex relationships, the authors suggest that a combination of qualitative, quantitative and longitudinal studies will enhance the literature in the field.

The potential of KM to influence innovation and achieve competitive advantage increases significantly with effective KM approaches. Moreover, the implementation process for KM makes all the difference. The cases demonstrated sound KM practices across some but not all of the various building blocks of innovation. In order to contribute to systematic innovation capability, KM practices should address as many attributes of innovation as possible. The large scale survey results provided useful insights into the innovation activities and practices of top innovation performers, and highlighted the role of sound knowledge management in supporting innovation efforts.

The greater the extent to which KM supports the various attributes and activities of systematic innovation, the more likely it is that KM performs an integrated and holistic function within an organization. Organizations that embed KM practices across a range of innovation activities create a boundary spanning culture, which links various organizational domains. These links are vital to the process of increasing KM's contributions to systematic innovation capability. This exploratory research confirms the complexity of the relationship between KM and innovation process, and how people's knowledge, thinking and behavior influence the process of innovation in different ways.

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Chapter 2
Connecting Knowledge Management and Entrepreneurship:
Processes and Technology

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ABSTRACT

This chapter reviews examples of how technologies that support knowledge management (KM) can link it to entrepreneurship, and in doing so, can increase the possibility of connecting domains that have traditionally been separated, both in the literature and in the practice of entrepreneurship. In particular, authors describe the utilization of KM processes and tools in a variety of organizations. They also link extant models of processes that support KM and entrepreneurship and propose their integration. Previous work examined the uneven track record of KM utilization in entrepreneurial organizations. In this analysis, authors take a broader view of its application with a specific eye towards KM technologies and by linking entrepreneurial and KM processes of new ventures.

DOI: 10.4018/978-1-7998-2355-1.ch002

INTRODUCTION

In this chapter, we review examples of how technologies that support knowledge management (KM) can link it to entrepreneurship, and in doing so, can increase the possibility of connecting domains that have traditionally been separated, both in the literature and in the practice of entrepreneurship. In particular, we describe the utilization of KM processes and tools in a variety of organizations. We also link extant models of processes that support KM and entrepreneurship and propose their integration. Previous work examined the uneven track record of KM utilization in entrepreneurial organizations. In this analysis, we take a broader view of its application with a specific eye towards KM technologies and by linking entrepreneurial and KM processes of new ventures.

Knowledge Management and Entrepreneurship

The link between Knowledge Management (KM) and entrepreneurship is a tale of mixed results as put forth by prior work (Bandera, Passerini et al. 2019). We further explore these mixed results using a digital lens and connecting KM and entrepreneurship though the processes and technologies that support them. Ways in which this support manifests, discussed below, include supporting knowledge sharing and creating new ventures, creating new digitally mediated collaborative working relationships, and reviving faltering organizational units or enabling technology-supported spin-offs.

It is the general consensus of researchers and practitioners that KM is facilitated with the use of information technology (I/T). I/T systems facilitate the creation of new enterprises and may play an instrumental role in indirectly linking KM and entrepreneurship. Solomon and Linton (Solomon and Linton 2016) point out that "while expansions and implosions of individual small business many not be eye-catching on an individual basis, the cumulative social and economic benefits provided by entrepreneurial and small firms engaging with technology and innovation is substantial."

Supporting Knowledge Sharing

New technologies, such as wikis, are being utilized to foster the institutionalization of knowledge and its easy dissemination across an organization. Some of this knowledge is scientific in nature and Pillay and Barnard (Pillay and Barnard 2019) state that "Entrepreneurs extensively consume scientific research, particularly to expand their knowledge bases. … collaboration between entrepreneurs and universities can unlock further opportunities in this regard." While the exchange of knowledge between enterprises and academia can be a factor in entrepreneurial success, there are constraints on this process. Sinell, et al. (Sinell, Müller-Wieland et al. 2018) point out that a hostile organizational structure, a lack of time and financial resources, and a lack of human resources all serve to hinder the process linking academia and fledgling companies. Despite the potential use of KM tools for knowledge sharing, these constraints can be rather substantial to overcome.

Argyris and Ransbotham (Argyris and Ransbotham 2016) explored the use of wikis in organizations for knowledge gathering and dissemination. Although wiki-based technology has been utilized for many years on the broader Internet to collect and disseminate knowledge, its application in new small ventures in general represents a more recent trend. Their work identified two critical elements to the use of wikis in such small organizations. The first of these they termed the need for one or more "enablers" among organizational leadership that foster the use of wikis. One might say that this person is an I/T leader in the organization or higher-level manager who sees the benefits of utilizing wikis for KM. In an entrepreneurial organization with a relatively flat structure, one can easily see the use of a wiki becoming commonplace quickly and its advantages allowing for the fostering of growth. Argyris and Ransbotham also identified that "inhibitors" exist in organizations that deter the use of wikis. They inhibit the institutionalizing of knowledge that wikis promote. It is suggested in their work that middle management may be a common source for inhibitors. This may position flatter organizational structures, such as startups and new ventures, in an advantageous position.

Creating new Digitally Mediated Working Relationships

I/T also enables temporary collaborative arrangements, whether between startup companies and educational institutions as mentioned above, that are similar to those temporary arrangements among competitors that may agree to share trucks in transportation logistics for deliveries to shared customers (Kayikci and Stix 2014), or joint ventures between organizations with complementary strengths. The collaborations rely on KM to underpin their successful operation. Pillay and Barnard (Pillay and Barnard 2019) further state that the creation of such knowledge requires certain competencies: speed in that participating organizations must be able to process vast amounts of information quickly and efficiently, the creativity to be able to generate novel ideas that are created from processed information, and the ability to stay ahead of emerging trends through innovation.

Reviving Faltering Units or Enabling Spin-Offs

An area where KM can be utilized in an entrepreneurial manner to "renew" a company is in the biotechnology industry. Joshi (Joshi 2018) details the nature of an aspect of KM termed "technological learning" (TL) in the Indian biotechnology industry. TL is defined as "the process by which a technology-driven firm creates, renews, and upgrades its latent and currently used capabilities based on its stock of explicit and tacit resources" (Carayannis, Popescu et al. 2006). Joshi explains that firms enter into various forms of collaborative alliances where KM is key to their ultimate success. Their study utilized interviews of company employees in the industry and brought to light a very interesting result: that despite the need to utilize TL to capture and share knowledge, its application for this purpose was less than would be expected and sporadic given the fast-paced nature of the industry and the resulting erosion of the knowledge base over a shorter period of time.

An interesting study by Azad and Majolan (Azad and Majolan 2012) examined the effects of KM on organizational entrepreneurship in the educational system in Iran. The authors studied the relationship between entrepreneurship and KM components. Their results pointed out, quite predictably, that knowledge content is the most influential factor affecting the degree of organizational entrepreneurship in the country's education system. This factor was followed by two others including the knowledge tools utilized and the concept of what knowledge consists of. The results fit with the general notion in the literature that KM is applicable to the growth of an organization. Knowledge must be timely, relevant, and possess the ability to be acted upon in order to foster entrepreneurship in any organization, be it an educational system or the biotechnology industry.

An additional relevant work based in Iran dealt with the effect of KM on organizational entrepreneurship in the agriculture industry (Korani 2018). This work sought to identify key knowledge components that corresponded to entrepreneurial activities in agriculture in the Kermanshah Province of the country. A survey instrument was utilized with agricultural extension experts in the region under study. A statistical analysis of the results revealed that knowledge creation, knowledge acquisition, knowledge organizing, knowledge storage, and knowledge application had significant correlations with organizational entrepreneurship. Again, these results are somewhat predictable, but still reinforce the notion of the main drivers behind the links between KM and entrepreneurship.

KM PORTALS FOR ENTREPRENEURSHIP: EUROPA'S BUSINESS INNOVATION PORTAL

One way for KM to benefit entrepreneurial activity is by supporting an infrastructure of knowledge creation and sharing of resources available to new entrepreneurs. To this effect, the European Union has launched an innovation portal to assist knowledge capture and dissemination of any information (from funding to market opportunities and regional economic studies) to support regional and transnational entrepreneurial growth. Among the many information tools available on the portal, a key contribution of the site is the systematic production and dissemination of case studies and examples of successful companies in emerging sectors, including sector-size studies that can be applied beyond the specific examples. Up to 12 cases are produced every six months (European Commission 2016) presenting an overview of opportunities and challenges across key innovation sectors. In particular, cases are developed in the areas of sustainability, access to raw materials, technology, and service innovation and digitization.

Each innovation area is mapped with a user-friendly infographic of the industry lifecycle. Such approach reduces learning complexity and enables a quick understanding of the domain, providing an opportunity to expand or replicate the success stories (Figure 1). The business innovation portal then acts as a repository of key knowledge to enable innovation across critical EU interest areas, such as: collaborative economy, sustainable supply of materials, advanced materials, internet of things, sharing economy, social sustainability and design for innovation, clean technology, smart living, workplace innovation, big data, and many more. Examples of a typical case study include:

- explaining the trends and definitions
- socio-economic relevance (what is the size of the market?)
- drivers and obstacles for new firms providing solutions
- policy recommendation (at the country or EU level to drive the growth of the specific sector)
- examples of successful companies in the domain area (by awards, revenue, recognition etc.)

As an illustration, we focus on the case on "Design for social innovation (Case Study 16)" which presents an analysis of the impact of designing new companies with the overall objective of finding novel solutions to social problems. This is a particularly interesting case as it focuses on companies that are not driven by wealth accumulation for the private sector but rather their goal is to launch social

Figure 1. European Union innovation and entrepreneurship portal (a and b)

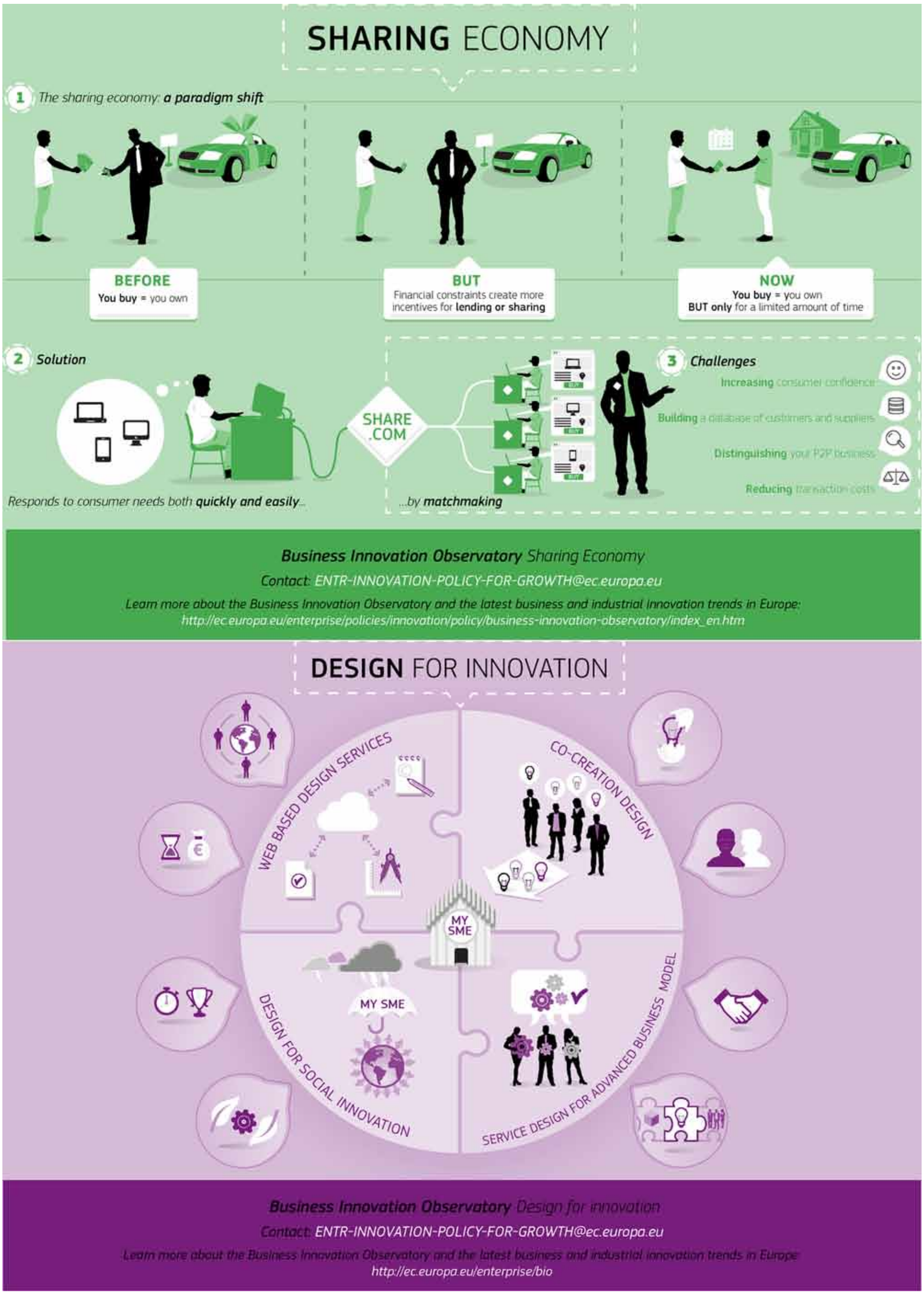


Table 1. Design for social innovation companies

Company	Location	Problem to solve	Business Innovation	Outcomes
Raspberry Pi	UK	Founded by academics at the University of Cambridge to counter the decline of STEM know-how by developing a tiny and cheap computer designed to teach kids basic programming skills	A charity foundation that designed and currently licenses a cheap credit card sized computer to teach children programming skills.	Sold millions of units and enabled self-paced learning
SNE Architects	Denmark	Increased flooding to be countered by new designs of drainage systems that can be effective for periodic overflows while being used as dynamic recreational spaces for the rest of the year	Experimental combination of drainage of rainwater and recreation area	Design awards
Aldebaran Robotics	France	Engaging human robots to drive students towards robotics and stimulate them to pursue a degree in technology, with pricing that is affordable by most institutions	Humanoid robot for teaching and academic purposes worldwide (NAO)	Exported to over 40 countries
RehabCare	Ireland	Need to develop person-centric solutions with assistive technology (i.e. sensor based or reactive) to help disadvantages people	Health center for those disadvantaged to participate in the life of their local community in ways that match their choices	3,000 people rehabilitated every year

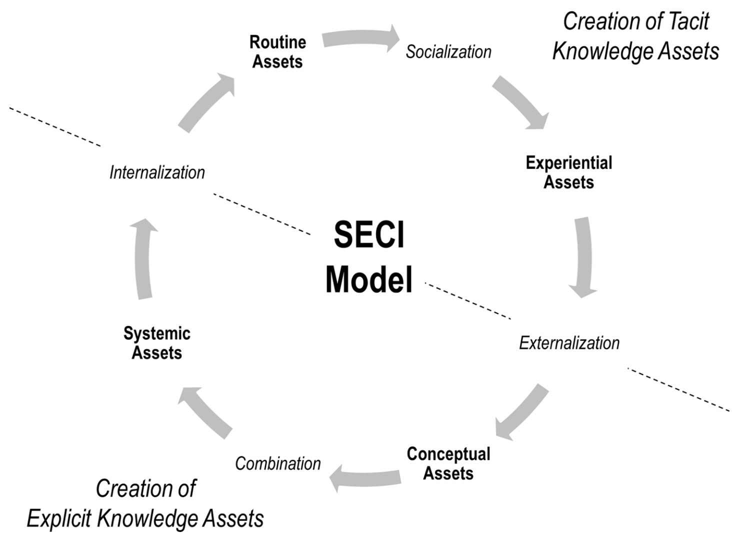
Source: adapted from (Dervojeda, Verzijl et al. 2014)

innovation through new market creation and raising awareness about macro-level problems (Table 1).

After providing an average of five-six startup examples, each case study presents the typical obstacles that must be addressed. In the case of designing for social innovation (Case 16) they include supporting a culture focused on social good, in addition to economic sustainability; and being able to raise capital for social entrepreneurship; scaling from localized examples to regional innovation; and building the ability to expand beyond the local. Finally, each case illustrates policy recommendations to drive EU action. In the specific scenario, it suggests replicating innovation program such as the famous NSF-SBIR program in the US (Small Business Innovation Research). The SBIR is seen as an effective a mechanism to initially fund innovations such as those described, before they reach market sustainability.

The above represents an application of KM principles, organization, and tools to the development and maintenance of large-scale knowledge repositories to drive

Figure 2. SECI model of knowledge creation. Activities shown in italics and assets in bold.



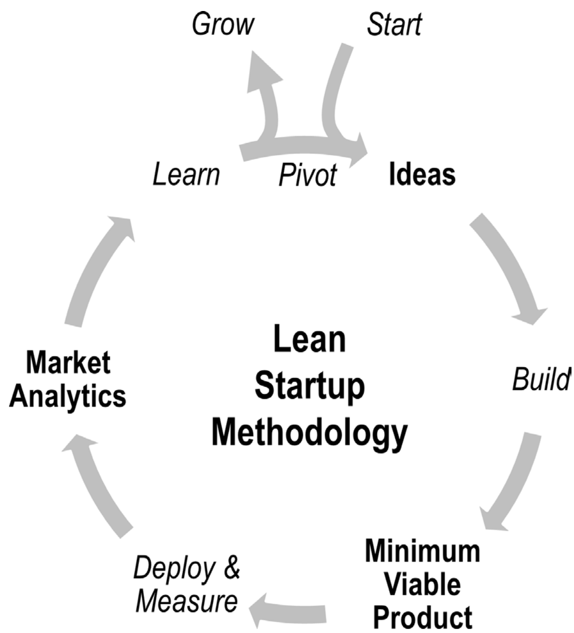
startups and entrepreneurial growth by facilitating knowledge access and distribution in a seamless and replicable way for nascent entrepreneurs.

Towards a Unified KM and Entrepreneurship Model

In (Bandera, Bartolacci et al. 2019), the authors present Nonaka's SECI model of knowledge creation (Nonaka, Toyama et al. 2000), originally developed in the context of the established corporations, and adapt it to the context of new ventures. The tacit and explicit knowledge products in a new venture, and the activities performed by members of the venture that produce these knowledge products, also map into the socialization, externalization, combination, and internalization quadrants of the SECI knowledge creation cycle (Figure 2). For example, socialization yields tacit knowledge assets such as recognized business opportunities, externalization yields explicit knowledge assets such as prototype designs and patents, combination yields explicit knowledge assets such as business plans and minimum viable products, and internalization yields tacit knowledge assets such as skills. However, established organizations and startups differ in fundamental ways. How does this impact their corresponding KM models, and is there a unified KM model that can represent them both?

In the prelude to the lean startup methodology (LSM), Ries (Ries 2011) argues that such startups are not small versions of established corporations, and should

Figure 3. The lean startup methodology's build-measure-learn cycle for testing business models



not be managed with similar practices. Instead, he argues that whereas established corporations execute a proven business model, startups face uncertainty in the business model that can only be resolved through experimentation with the target markets. He further defines a startup as an experiment designed to test a business model; a startup becomes a small business when its business model is proven.

Rarely is the risk in entrepreneurship that the innovative product or service might not work. Instead, the risk is that it might not sell. Innovation introduces uncertainty in the form of unproven assumptions into each of the blocks of the business model canvas (Osterwalder and Pigneur 2010), all of which must hold true for the venture to be successful. Since it is unlikely that all the assumptions will hold, the entrepreneur must test them with the limited resources (time, staff, social network, and finances) at his/her disposal, and revise the business model (i.e., pivot) when an assumption is found to be wrong.

The practices with which an entrepreneur can test a business model are fundamentally different from – and not simply small-scale implantations of – the management practices of an established corporation. For example, the entrepreneur must avoid anything that involves economies of scale, because any such investment will likely be wrong until s/he proves the business model. Indeed, until that moment, the entrepreneur trades financial efficiency for the ability to iterate quickly through a cycle of (1) building a minimum viable company, which is more than just a minimum viable product, (2) deploying the company to the market and measuring the market's response, and (3) determining from this response if the startup should pivot or transition to growth (Figure 3). Correspondingly, the knowledge creation and management practices of entrepreneurship in the startup phase are very different from those in the venture's subsequent small business phase.

Knowledge building activities are in italics, and knowledge work products are in bold.

It is possible to formulate an integrated model of knowledge creation and management that combines the startup and small business phases of entrepreneurship, yet distinguishes these phases. A legitimate question to ask is why bother combining these two phases into a model if they are so different? The answer lies in the reasons why entrepreneurs fail to leave the startup phase, also known as the "valley of death" (Markham, Ward et al. 2010).

The most common reason for entrepreneurial failure we have already addressed: incorrect assumptions in the business model, which lead to an unresponsive market. Here, the entrepreneur bypassed the build-measure-learn cycle of the lean startup methodology, and instead commercially introduced an innovation to a target market incorrectly assuming that the market would want the innovation.

A second reason for entrepreneurial failure is that the entrepreneur fails to switch from managing a startup to managing a small business. This second reason is particularly heartbreaking because it happens to those blessed startups who were able to successfully validate their business model with their limited resources. Instead of transitioning to economies of scale and profit, these startups with validated business models continue to pivot until they run out of resources. In other words, the first reason for failure is that the entrepreneur bypasses the LSM cycle, whereas the second reason for failure is that the entrepreneur never leaves it.

An integrated model of knowledge creation and management explicitly represents the entrepreneur's tacit and explicit knowledge work products before and after her/his exit from the valley of death, i.e., the transition from startup to small business, as well as the processes that yield these work products. The ability to compare these startup and small business knowledge products and processes within a common framework makes the model of greater value to the researcher, the practitioner, the educator, and the policy maker.

To a certain extent, the progression of knowledge building activities in the lean startup methodology and in the SECI model are similar. They both begin with tacit knowledge assets, namely the insights of the entrepreneur, which may have originated from prior non-startup experiences (Bandera, Keshtkar et al. 2018). The entrepreneur builds additional insights into opportunities and strategic directions through socialization, which is one of the SECI quadrants. From these insights, the startup builds its first explicit assets, including prototypical designs and initial investor material. Because these first assets were generated from the entrepreneur's tacit assets, they fall into the externalization quadrant of the SECI model which follows socialization.

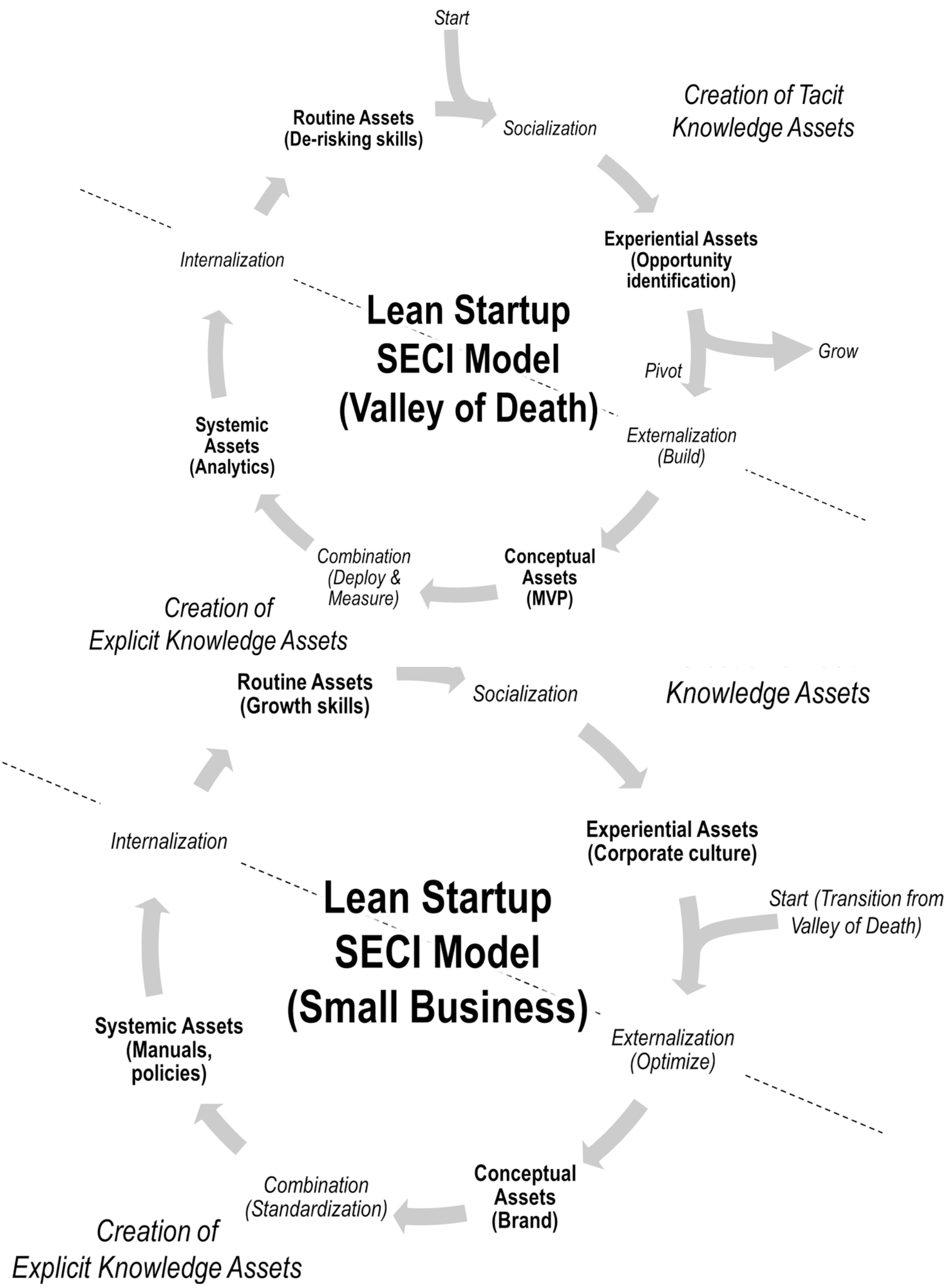
The minimum viable product is also an explicit asset, but because it is built from the explicit assets generated by externalization, the MVP and the LSM build activity are associated with the combination quadrant of the SECI model. The market analytics collected in the LSM cycle are also explicit assets derived from prior explicit assets, including the MVP and customer behavior tracking mechanisms, and are also associated with the SECI's combination quadrant.

Beyond the aforementioned sequence of activities, however, the progression of knowledge building activities in the lean startup methodology is different from that of the SECI model. Many of the activities in the last SECI quadrant, internalization, are associated with economies of scale. These activities include production and following standard operating procedures (explicit knowledge assets), which yields new tacit knowledge such as skills. However, the startup has to avoid any economy of scale until it proves its business model. The more likely strategic decision by the entrepreneur whose startup has collected market/MVP analytics is to pivot, which brings the startup back to socialization.

The above is not to say that internalization is not important to entrepreneurship. Quite to the contrary, it is well known in entrepreneurship research and in the startup investment community that prior startup experience is strongly associated with an entrepreneur's likelihood of success with a new venture (Oe and Mitsuhashi 2013). This experience is a tacit knowledge asset, and only two SECI quadrants yield tacit knowledge assets – socialization and internalization. However, only internalization is the culmination of knowledge generated within a company (new venture or otherwise). Even when startups fail, and perhaps especially then, entrepreneurs acquire tacit knowledge (Cope 2011). This valued tacit knowledge is not associated with economies of scale. Instead, it is associated with the often-cited expression that successful entrepreneurs work on their companies, not in their companies (Gerber 2003).

Figure 4 illustrates the SECI model redrawn to represent the knowledge creation activities and resulting knowledge assets in a startup while it is in the valley of death (top) and when it graduates from being a startup searching for a working business model to being a small business searching for efficient ways to execute a proven business model. The SECI framework is the same in the two stages of the venture, but the strategic objectives and assets are very different. With the due differentiation, KM processes drive entrepreneurial activities differently across stages of growth of the startup versus the small business.

Figure 4. Lean Startup - SECI model of entrepreneurship in the startup (a) and after proving the business model (b).



CONCLUSION

This work takes a broad look at the links between knowledge management (KM) and entrepreneurship. In particular, it examines a range of entrepreneurial activities in which information technology plays a key role in the dissemination of knowledge across organizations. Unlike previous work, it does not focus on a single model of KM in fledgling organizations but provides a wider perspective on how KM processes and technology facilitate entrepreneurial activities as these change strategically over time, in particular during the transition from business model validation to efficiency. While it remains clear that the literature on KM and entrepreneurship remains scattered and focused on technology-mediated connections, a careful review of fundamental KM and entrepreneurial processes (the SECI model and the Lean Startup framework) shows that these processes are synchronized. These overlaps represent the starting points of future investigations on how to transform any startup process into a knowledge-intensive and lessons-learned rich framework.

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Chapter 3

Innovation as a Mediator Between Knowledge Management and Organisational Performance:

Knowledge Acquisition, Knowledge Application, and Innovation Towards the Ability to Adapt to Change

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ABSTRACT

This chapter provides important empirical evidence to support the role of individual knowledge management processes and separate innovation types within firms. Specifically, knowledge acquisition and knowledge application are analyzed and empirically tested in relation to product and process innovation as well as business performance. The results support the direct impact of product and process innovation on business performance. In addition, the results show the indirect effect of knowledge acquisition and knowledge application on firm business performance through product and process innovation.

DOI: 10.4018/978-1-7998-2355-1.ch003

INTRODUCTION

Development of information technology (IT) has contributed to the transformation of economies, societies, and business environments (Martín-de Castro, 2015). These changes have not only affected some or leading sectors, but all economic sectors have received new tools that significantly influence business processes (Cohen, DeLong, & Zysman, 2000). In other words, information technology has transformed all industries with different levels of influence. Brynjolfsson and Kahin (2000) state that the new era refers to the transformation of all sectors of the economy under the influence of, first of all, computers that have enabled digitization of data. This new era is known as: the digital economy, the new economy, the information economy, the knowledge-based economy, etc. What is most important in observing business of the new era are continuous and dynamic changes. Luftman, Lewis, and Oldach (1993) state that the world is experiencing profound changes and only things that are not changing are the changes themselves (Alpay *et al.*, 2012). These changes bring challenges and opportunities with them (Luftman, Lewis and Oldach, 1993). Many of these changes require a dramatic formation of business processes and activities in order to enable control of challenges and exploitation of opportunities.

Because of that, knowledge has become an essential strategic asset that distinguishes economies, societies, and firms (Hsu and Sabherwal, 2011). However, knowledge implies a productive application of information through the ability to convert information into decisions and actions (Pandey and Dutta, 2013). Thus, Darroch (2005) highlighted that „*simply owning resources is not necessarily going to provide any kind of advantage to the firm*“. In other words, knowledge contributes to creating added value for a firm only when used. The most common form of value-added creation in the new era is innovation. Therefore, knowledge management (KM) has been seen as an essential concept and according to many authors, a source of innovation (Carneiro 2000; Kalotra 2014; Darroch 2005).

(Lopes *et al.*, 2017) emphasize that for organizational sustainability, the organization should focus on knowledge and innovation management. Specifically, knowledge-based innovations enable the creation of a sustainable basis for competitiveness in organizations. Innovative firms support new ideas and change, encourage risk-taking and new business approaches (Tsai and Yang, 2014). Besides using their strengths, these firms are always looking for new opportunities (Dibrell, Craig and Hansen, 2011) and they are more capable of developing creative solutions than their competitors which contributes to the business success (Hult, Hurley and Knight, 2004). Knowledge management and innovation are widely considered to be valuable capabilities associated with the competitive advantage and superior business performance (Chen and Huang, 2009; Chen and Huang, 2012). Thus, this relationship has been well established in the literature. However, this study aims to analyze whether processes of knowledge acquisition and knowledge application could have the freestanding influence on product and process innovation. There is a lack of research demonstrating how they work together to enhance business performance, especially when it comes to specific types of innovation as product and process innovation. Consequently, the main objective of this paper is to provide important empirical evidence to support the role of knowledge acquisition and knowledge application for both product and process innovation within firms. Besides, the effect of knowledge acquisition, knowledge application, and product and process innovation on organizational business performance would be analyzed. Also, these relationships would be analyzed and empirically tested in the context of the transitional economy. Instead of direct effects, this study investigates the mediating effect of product and process innovation between knowledge acquisition and performance as well as between knowledge application and business performance. We examine the direct impact of both KM processes and innovation types on firm business performance. In addition, we explore the role of product and process innovation as a mediating mechanism to explain the effect of knowledge acquisition and knowledge application on firm's business performance.

BACKGROUND

This study has drawn on the resource-based view (RBV) to explain the relationships between the knowledge management processes (Ferreira, Mueller and Papa, 2018), product and process innovation and firm business performance. According to this theory, competitive advantage and firm success depend on the resources that the firm owns and uses in its business (Papa *et al.*, 2018). The resources are competencies and capabilities that are specific to the firm and which firm can utilize more efficiently and effectively than its competitors (Barney and Clark, 2007). Kull, Mena and Korschun (2016) discuss that RBV adopts the internally driven approach and relies on the internal resources as the firm's primary drivers of its sustainable competitive advantage. However, utilization of resources in the New era depends on the business environment and its dynamism. Therefore, the resource-based view indicates that firms should match their capabilities to external conditions to achieve competitive advantage (Droge, Calantone and Harmancioglu, 2008). A number of resources or assets and capabilities that can enable and facilitate the development of core competencies (Kull, Mena and Korschun, 2016) are recognized by literature as means for firms' success. However, when it comes to contemporary firms and the New era, knowledge and innovation are among key resources that drive firm's success. Thus, Varis and Littunen (2010) note that the ability of firms to adapt to the external environment and to achieve sustainable competitiveness is closely related to their capacity to innovate and continuously upgrade and renew their knowledge bases. The antecedent of every innovation is either the generation of new knowledge or the combination of existing pieces of knowledge (Varis and Littunen, 2010).

Knowledge Management

Nowadays, knowledge management (KM) is given considerable attention both from an academic community and the business world. Knowledge and successful knowledge management are considered as the sources of competitive advantage and business success (Cohen & Olsen 2014; Lee et al. 2016). The concept of knowledge management in a firm consists of a series of processes, from adoption to using and knowledge retention.

Many authors have explored the importance of successful knowledge management in a firm, and the general conclusion is that, in order to maintain its competitive advantage in a dynamic environment, the firm must develop knowledge management capability, i.e., ability to create and modify knowledge over time (Chen and Fong, 2013). Recent research highlights the need to develop the concept of knowledge management capability (Lichtenthaler and Lichtenthaler, 2009) which involves researching, assimilating and exploiting knowledge both inside and outside a firm. The conversion from know-how to knowledge constitutes knowledge management, and it drives performance. By building core competencies and strategic know-how, the firm starts to recognize knowledge as capability (Lee, Lanting and Rojdamrongratana, 2016). KM capability can be observed through the existence of knowledge management processes of which the acquisition and application of knowledge are most important or the initial and final processes of KM.

- **Knowledge Acquisition:** Refers to the processes of identifying critical capabilities, types of knowledge, and individuals with the necessary expertise and their adoption. It represents the ability to discern valuable internal and external knowledge, and absorb it (Liao and Wu, 2009).
- **Knowledge Application:** Involves processes that address finding and using knowledge in the business processes of a firm. It Is actual use of knowledge to adjust strategic direction, solve new problems, and improve efficiency (Wang, Klein and Jiang, 2007).

Innovation

Firm's capability to generate innovation has long been recognized in the literature as one of the key determinants of a successful business (Ellonen *et al*. 2008; Wang and Ahmed 2004). Varis and Littunen (2010) claim that "*innovation is the elixir of* *life for firms, regardless of their size or other attributes*". Continuous innovation has become a necessity if firms want to remain competitive. Innovations are defined as "*the generation, acceptance, and implementation of new ideas, processes, products or services*" (Mavondo, Chimhanzi and Stewart, 2005). Johannessen et al. (2001) indicate that three essential questions should be answered when determining and measuring innovation: (1) what is new; (2) how much is new; and (3) for whom it is new.

Innovation has become necessary for maintaining competitive advantage towards many authors and studies, and especially for companies in the new era (Ellonen, Blomqvist and Puumalainen, 2008). Firms cannot survive in a dynamic environment without the continuously innovating their business. Depending on the research, it is possible to find the following categories and types of innovations: product innovation, process innovation, marketing innovation, behavioral innovation, organizational innovation, social innovation and strategic innovation. According to most authors of the earlier research, the concept of innovation can be viewed through two main categories: product innovation and process innovation (Mavondo, Chimhanzi and Stewart, 2005).

- **Product Innovation:** Refers to something new and innovative in a product offered on the market at the right time (Wang and Ahmed, 2004).
- **Process Innovation:** Implies the implementation of new or significantly improved production, delivery or other business processes.

Hypotheses Development

This paper examines the role of knowledge acquisition and knowledge application in two ways. First, the paper examines the RBV suggestion that effective knowledge management supports the successful business performance. Second, effective knowledge management enhances innovation in a firm. In addition, the paper examines the role of innovation in the firm's business performance.

With guidance from the extant literature, this paper proposes a positive relationship between the knowledge management capability and business performance as well as between innovation and business performance. That is, a firm with effective knowledge management or higher KM capability will have better business performance. Similarly, a firm with higher innovation capability will achieve greater levels of business performance. Previous studies have analyzed the impact of innovation on the business performance and found out that greater innovation contributes to increased business performance (Bolivar-Ramos, Garcia-Morales and Garcia-Sanchez, 2012). Since innovative firms promote change, it is likely that they will continually improve their business and production processes and to innovate their products and services.

With continuous improvement, firms can increase the efficiency and effectiveness of various functions based on which it is predicted that firms with more innovative capability will achieve better business performance (Tsai and Yang, 2014). Thus, we suggest following hypotheses:

- H1a. Knowledge acquisition positively affects business performance.
- H1b. Knowledge application positively affects business performance
- H2a. Product innovation positively affects business performance.
- H2b. Process innovation positively affects business performance.

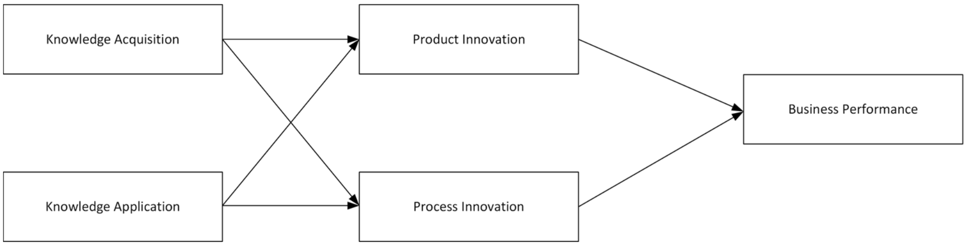
In addition to having a direct impact on the firm's business performance and competitiveness, knowledge management is also considered to have an impact on other organizational capabilities. Thus, Chen & Huang (2009) analyzed the relationship between knowledge management and innovation emphasizing that the process of innovation involves acquiring, disseminating and using new and existing knowledge and that it is closely related to the firm's capability to capitalize on its knowledge. Knowledge is the basis of innovation, knowledge management can help companies respond to ongoing changes in the business environment and improve their competitive advantage (Huang *et al.*, 2011). Innovation is the ability of a firm to discover, experiment and develop new technologies, new products and services and business processes. The process of innovation in itself implies something new and therefore the acquisition of knowledge (Chen, Huang and Hsiao, 2010). For this reason, knowledge management is the source of innovation. Consequently, we propose the hypothesis:

- H3a. Knowledge acquisition positively affects product innovation.
- H3b. Knowledge application positively affects product innovation.
- H4a. Knowledge acquisition positively affects process innovation.
- H4b. Knowledge application positively affects process innovation.

Proposed conceptual model is presented in Figure 1.

In addition to the direct impact of KM processes on business performance, proposed hypotheses imply that product and process innovation mediate the relationship between knowledge acquisition and business performance as well as the relationship between knowledge application and business performance. Mediation effect analysis can generate one of three possible results: no mediation effect, partial mediation effect, and full mediation effect. Full mediating effect exists when there are significant relationships between independent variable and mediator and between the mediator and dependent variable while the relationship between independent and dependent variable is not significant. Partial mediation effect exists when all relationships are

Figure 1. Proposed conceptual model



significant: between independent variable and mediator, between the mediator and the dependent variable, and between independent and dependent variable (Iacobucci, Saldanha and Deng, 2007). Thus, we suggest following hypotheses:

- H5a. Product innovation mediates the relationship between knowledge acquisition and business performance.
- H5b. Process innovation mediates the relationship between knowledge acquisition and business performance.
- H6a. Product innovation mediates the relationship between knowledge application and business performance.
- H6b. Process innovation mediates the relationship between knowledge application and business performance

Research Design

We selected 2,966 small, medium and large firms for the sample and some of the micro firms belonging to innovative sectors of the industry, such as the IT sector, as well as certain firms that are micro in terms of a number of employees but they are part of larger international firms. To improve the validity of the survey questions, we pretested the questionnaire. A pretest involving two executives and four academics was conducted to assess the content and face validity of the measurement items. Consequently, several modifications were made in order to clarify the notion of a specific item. Web-based survey software was used for the data collection. The survey was mailed to firms' managers together with an invitation letter explaining the purpose of the study and guaranteeing the confidentiality of the respondents. Managers have been chosen as respondents because previous studies have shown that senior managers are reliable in their evaluations of their firm's activities and performance (Hooley and Greenley, 2005). The sample consisted 427 questionnaires after removal of the questionnaires with more than 20% of missing data (Hair *et al.*, 2010). This response rate of 14.40% is reasonable since the targeted respondents were executives (Goktan and Miles, 2011). The structure of the sample is: 7% of micro firms, 39% of small firms, 39% of medium firms and 15% of large firms. Size of the sample is adequate considering the number of indicators (Velicer and Fava 1998; Hair *et al.* 2010). In addition, in order to check whether the sample represents the population in the right way, a chi-square test for non-response bias is performed. The firms that responded after the first call was compared to those that responded the questionnaire after the second reminder. Later respondents, in general, have similar characteristics to those who did not respond to the questionnaire and thus to the characteristics of the general population (Chuang, Liao and Lin, 2013). The results of the Chi-square test showed that there is no significant difference between the two groups of respondents for the number of employees ($\chi 2 = 3.324$, $p = 0.344$) at the level of significance of 5%.

Measures

For the purpose of this study, we measured the five constructs: knowledge acquisition, knowledge application, product innovation, process innovation and business performance. We have used multiple-item scales adapted from previous studies using a seven-point Likert-type scale ranged from strongly disagree (1) to strongly agree (7). Knowledge acquisition and knowledge application measurement models are adapted from Liao and Wu (2009); product and process innovation are adopted from Ellonen *et al.* (2008), and financial business performance items are adopted from Chen *et al.* (2009).

We conducted confirmatory factor analysis (CFA) separately for each measurement model. This approach was selected to assess the reliability, convergent and discriminant validity of the constructs which is consistent with prior studies (Hult *et al.* 2004; Hooley and Greenley 2005; Battor and Battor 2010). The CFA results show that all indicators loaded significantly on their corresponding latent construct and models fit the data well. We calculated the composite reliability (CR) to estimate consistency on the basis of construct loadings (Fornell and Larcker, 1981). All the scale items are provided in Table 1 together with the α, CR and AVE values confirming reliability as well as the convergent and discriminant validity of the measurement models (Hair *et al.*, 2010).

As shown in Table 1, the CR values ranged from 0.87 to 0.90 exceeding the acceptable level of >0.7 for construct reliability (Fornell and Larcker 1981; Bagozzi *et al.* 1991). Also, the AVE values ranged from 0.54 to 0.70 exceeding the acceptable level of >0.5 for construct convergent validity (Fornell and Larcker 1981). In addition, discriminant validity has been tested using the square root of average variance extracted (AVE) value and comparing it to the correlations which are presented in Table 2 (Hair *et al.*, 2010). Discriminant validity is confirmed for

Table 1. Scales' Items with α, CR, and AVE values

Factor	Item	α	CR	AVE
Knowledge Acquisition (KMA)	Our firm has processes for acquiring knowledge about our suppliers (and customers).	0.866	0.878	0.549
	Our firm uses feedback from projects to improve subsequent projects.			
	Our firm has processes for exchanging knowledge with our business partners.			
	Our firm has processes for acquiring knowledge about new product/ services within our industry.			
	Our firm has teams devoted to identifying best practice.			
	Our firm has processes for absorbing knowledge form individuals into the organization.			
Knowledge Application (KMP)	Our firm uses knowledge to improve efficiency.	0.901	0.903	0.700
	Our firm is able to locate and apply knowledge to changing competitive conditions.			
	Our firm makes knowledge accessible to those who need it.			
	Our firm quickly links sources of knowledge in solving problems.			
Product Innovation (PROD)	During the past five years, my firm has introduced more innovative products and services than its competitors.	0.897	0.899	0.691
	The new products and services of my firm are often perceived as very novel and innovative by customers.			
	In new product and service introductions, my firm is often first-to-market.			
	My firm has recorded growth in the introduction of new products/ services over the past 5 years.			
Process Innovation (PROC)	My firm improves its business processes constantly.	0.867	0.870	0.627
	During the past five years, my firm has developed many new management approaches.			
	When a problem cannot be solved using conventional methods, people in my firm invent new methods.			
	My firm changes the production methods faster than its competitors.			
Business Performance (BP)	Generally speaking, for the past few years, we have enhanced return on investment.	0.889	0.893	0.630
	Generally speaking, for the past few years, we have enhanced sales and profitability of the firm.			
	Generally speaking, for the past few years, we have been profitable.			
	Generally speaking, for the past few years, we have achieved profit objectives.			
	Generally speaking, for the past few years, we have achieved market share objectives.			

Source: Authors' illustration (items adopted from Liao and Wu (2009); Ellonen et al. (2008); Kmieciak et al. (2012); Chen et al. (2009) considering the conceptualization of observed constructs).

Table 2. Constructs' Square Root of AVE values and correlations among constructs

Dimensions	*KMA*	*KMP*	*PROD*	*PROC*	*BP*
Knowledge Acquisition (KMA)	**0.741**				
Knowledge Application (KMP)	0.765*	**0.837**			
Product innovation (PROD)	0.525	0.581	**0.831**		
Process innovation (PROC)	0.707	0.667	0.722	**0.792**	
Firm's business performance (BP)	0.425	0.408	0.468	0.533	**0.794**

*note: KMA and KMP share a high level of variance because they are parts of the same concept: knowledge management, and we can neglect a small deviation of 0.02.

a construct if its AVE value is greater than its correlations with any other construct (Fornell and Larcker, 1981). The AVE is the amount of variance that is captured by the construct in relation to the amount of variance due to measurement error (Battor and Battor 2010; Fornell and Larcker 1981).

Due to the relatively high correlation between the items, it is recommended to assess whether the common method bias (CMB) is a problem in the research. It is possible to carry out several appropriate tests to address this issue. Harman's (1976) single factor test is one of the most commonly used techniques dealing with the analysis of common bias (Podsakoff *et al.*, 2003). First, exploratory factor analysis with all 24 variables has been conducted using the principal axis factoring method with varimax rotation. The EFA showed the presence of 4 different factors with an eigenvalue greater than 1.0. These four factors together account for 67.581% of total variance, and no general factor is apparent. Second, exploratory factor analysis with all 23 variables has been employed where the extraction of one factor is defined. The total variance of the explanation by one factor is below 50% (44%). Finally, confirmatory factor analysis has been conducted with a single-factor model and all 23 variables. The results of the CFA are: Chi-Square = 3,780.792; df = 230; RMSEA = 0.190; SRMR = 0.107; NFI = 0.869; CFI = 0.878. Although the results of these analyzes do not completely exclude the possibility of a common method bias, they suggest that the variance of the common method is not of great concern and is therefore to affect the results of the analysis. Therefore, measurement models meet the criteria of reliability and validity.

After providing support for the robustness of the measurement models, we conducted structural equation modeling (SEM) to test our proposed structural model and hypotheses. We used Lisrel 8.8 and SPSS 22 for the data analysis.

RESULTS AND DISCUSSION

We used SEM to test our hypotheses with the maximum likelihood (ML) estimation method. According to Iacobucci *et al*. (2007), SEM provides "*the state-of-the-art approach to testing for mediated relationships among constructs or variables particularly when multiple items have been measured to capture any of the focal constructs*". Furthermore, they imply that mediation effect analysis can generate one of three possible results: no mediation effect, partial mediation effect, and full mediation effect.

First, we explored the correlation matrix for the measurement models concluding that there is a significant positive correlation among all constructs. In addition, to check the data homoscedasticity, normality and collinearity, we conducted the Breusch-Pagan test, examined the skewness and kurtosis of all items and tested latent factors by calculating variance inflation factor (VIF). The results suggested the homoscedasticity of the data and small deviations from normality distribution. Hair *et al*. (2010) state that failure to meet the assumption of data normality can seriously affect the results of the analysis when it is done on a small sample ($n < 50$) while the impact is significantly reduced for samples of 200 or more observations. They also state that the ML method is rather robust in the deviation of data from the assumption of normality emphasizing that a certain number of authors compared the results of the ML method under different circumstances which undoubtedly indicate the reliability of the results obtained by the ML estimation method in the conditions when the data normality is not confirmed. Thus, we confirm that small deviations from data normality won't present the problem for this study given that we use ML estimation technique and that the sample consists 427 observations. The results also suggest that there is no significant problem of data multicollinearity.

SEM results are provided in Table 3. The results indicate a good overall fit with the data ($\chi 2/df=3.16$; RMSEA=0.0711; SRMR=0.06783; NFI=0.966; CFI=0.976). Since GOF indices are within acceptable levels, we concluded that the structural model is adequate for the hypotheses testing. The results support six out of eight hypotheses. The results imply that product innovation and process innovation significantly and positively influence firm business performance ($\beta=0.208$, $t=3.420$, $p=0.000$; $\beta=0.328$, $t=4.162$, $p=0.000$) providing support for H2a and H2b. Furthermore, knowledge acquisition significantly and positively impacts firm's product and process innovation ($\beta=0.234$, $t=2.965$, $p=0.003$; $\beta=0.473$, $t=6.195$, $p=0.000$) supporting hypotheses H3a and H4a. Similarly, knowledge application significantly and positively influences firm's product and process innovation ($\beta=0.417$, $t=5.258$, $p=0.000$; $\beta=0.316$, $t=4.364$, $p=0.000$) supporting hypotheses H3b and H4b. Relationships between KM processes of acquisition and application do not have a significant impact on firm business performance. Thus, the results imply that product and process innovation

Table 3. Results of the SEM analysis

Regression Weights	Unstandardized Estimates	Standardized Estimates	t - value	Hypothesis Supported?
H1a KMA ® BP	0.077	0.078	0.845	-
H1b KMP ® BP	0.015	0.014	0.160	-
H2a PROD ® BP	0.140	0.208***	3.420	+
H2b PROC ® BP	0.316	0.328***	4.162	+
H3a KMA ® PROD	0.346	0.234***	2.965	+
H3b KMP ® PROD	0.652	0.417***	5.258	+
H4a KMA ® PROC	0.487	0.473***	6.195	+
H4b KMP ® PROC	0.345	0.316***	4.364	+
Chi-Square=697.506; df=221; RMSEA=0.0711; SRMR=0.06783; NFI=0.966; CFI=0.976				

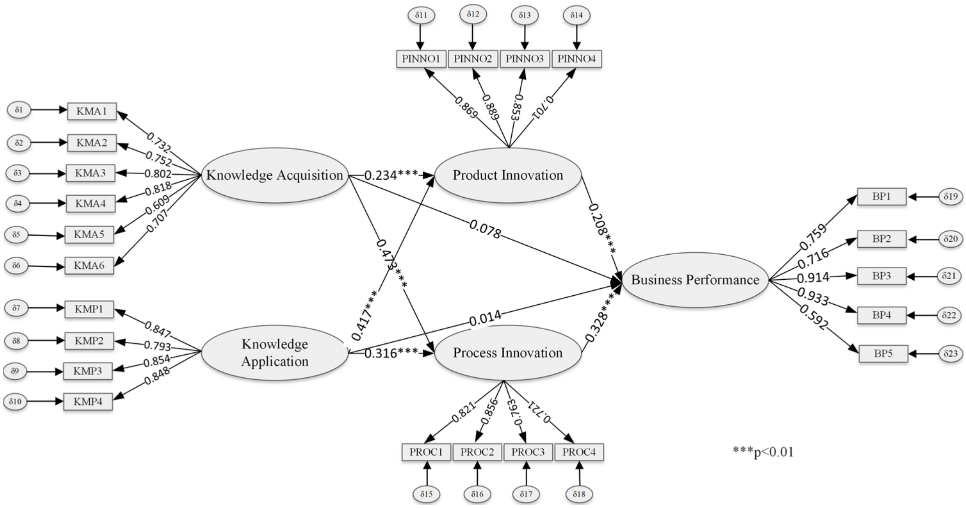
*p<0.1, **p<0.05, ***p<0.01

have a direct relationship with the performance but also play a mediating role in the relationship between KM processes and business performance. In other words, our results imply full mediation effects of product and process innovation between KM processes and business performance.

Full mediating effect exists when there are significant relationships between independent variable and mediator and between the mediator and dependent variable while the relationship between independent and dependent variable is not significant (Iacobucci, Saldanha and Deng, 2007). This practically means that knowledge acquisition and knowledge application enhance product and process innovation and in return, these innovations improve business performance in a firm.

In addition, to test the mediating effect, we followed the procedures suggested by Baron and Kenny (1986) and estimated two models. Knowledge acquisition positively influences business performance (model 1: β=0.271, t-value=3.127) and knowledge application as well (model 1: β=0.199, t-value=2.338). Besides, KMA positively influences product innovation (model 2: β=0.234, t-value=2.965) and process innovation (model 2: β=0.473, t-value=6.195). Similarly, KMP positively influences product innovation (model 2: β=0.417, t-value=5.258) and process innovation (model 2: β=0.316, t-value=4.364). Product (model 2: β=0.208, t-value=3.420) and process (model 2: β=0.328, t-value=4.162) innovation positively influence firm's business performance. Comparing Models 1 and 2, we found that the positive effect of KMA on BP in model 1 becomes insignificant in model 2 (β=0.078, t-value=0.845) as well as the effect of KMP on BP (β=0.014, t-value=0.160). Therefore, product and process innovation fully mediates the relationships between knowledge acquisition and business performance and between knowledge application and firm's business

Figure 2. Path diagram with path coefficients estimates and their significance levels



performance. To further confirm the mediating effects of PROD and PROC, we have utilized the effect decomposition during the structural model testing procedure and conducted Sobel's test (Sobel, 1982).

The findings show that both product and process innovation are significant mediators in driving the effect of KMA and KMP on business performance. Table 5 presents the total, indirect and direct effects of an independent variable on a dependent variable. A significant indirect effect implies that a significant amount of the independent variable's total effect on the dependent variable occurs via the mediator (Lin, Peng, & Kao, 2008).

In addition, in order to check the results of mediation effects proposed by this study, we used a bootstrapping method with bias-corrected confidence estimates (Preacher and Hayes, 2008). The indirect effect was obtained with 5000 bootstrap resamples by using the PROCESS procedure in SPSS, which allowed us to obtain the unstandardized estimates, 95% bias-corrected confidence intervals and P values (Preacher and Hayes, 2008; Zabkar *et al*. 2017). The results imply that both product and process innovation are significant mediators in driving the effect of KMA on business performance and the effect of KMP on business performance since the 95% bias-corrected confidence intervals do not include zero.

Finally, the model is controlled using firm age and number of employee variables. The firm size is relevant because it is expected for larger firms to exhibit greater levels of innovation with better performance than smaller firms. Similarly, older firms may possess greater experience with innovation than newer firms and thus achieve better performance (Kyrgidou and Spyropoulou, 2012). The results of this

Table 4. Testing mediating effects

Independent variables	Endogenous variables			
	Model 1	Model 2		
	BP	PROD	PROC	BP
KMA	0.271 (3.127***)	0.234 (2.965***)	0.473 (6.195***)	0.078 (0.845)
KMP	0.199 (2.338**)	0.417 (5.258***)	0.316 (4.364***)	0.014 (0.160)
PROD				0.208 (3.420***)
PROC				0.328 (4.162***)
BP				
Sobel t-test (PROD mediates relationship KMA ® BP): SE=0.022; t-value=2.235; p<0.05				
Sobel t-test (PROC mediates relationship KMA ® BP): SE=0.045; t-value=3.422; p<0.01				
Sobel t-test (PROD mediates relationship KMP ® BP): SE=0.032; t-value=2.828; p<0.01				
Sobel t-test (PROC mediates relationship KMP ® BP): SE=0.036; t-value=3.010; p<0.01				

*p<0.1, **p<0.05, ***p<0.01

Table 5. Decomposition of effects

Path	Unstandardized coefficients (t-values)			Standardized coefficients		
	Total Effect	Direct Effect	Indirect Effect	Total Effect	Direct Effect	Indirect Effect
H1a KMA ® BP	0.280 (3.257***)	0.077 (0.845)	0.202 (4.042***)	0.281	0.078	0.204
H1b KMP ® BP	0.216 (2.414***)	0.015 (0.160)	0.210 (4.046***)	0.205	0.014	0.190
H2a PROD ® BP	0.140 (3.420***)			0.208		
H2b PROC ® BP	0.316 (4.162***)			0.328		
H3a KMA ® PROD	0.346 (2.965***)			0.234		
H3b KMP ® PROD	0.652 (5.258***)			0.417		
H4a KMA ® PROC	0.487 (6.195***)			0.473		
H4b KMP ® PROC	0.345 (4.364***)			0.316		

*p < 0.1, **p < 0.05, ***p < 0.01

Table 6. Hypotheses testing (PROCESS procedure)

Hypotheses	β	SE	t	p	LLCI	ULCI
H5a KMA ® PROD ® BP	0.1159	0.0329	3.523	0.000	0.0570	0.1865
H5b KMA ® PROC ® BP	0.2006	0.0461	4.351	0.000	0.1149	0.2959
H6a KMP ® PROD ® BP	0.1300	0.0384	3.385	0.000	0.0593	0.2137
H6b KMP ® PROC ® BP	0.2104	0.0476	4.420	0.000	0.1256	0.3138

study show that firm's age doesn't have a statistically significant impact on business performance (β=-0.002; t=-0.037; p=0.970) while firm's size found to have a positive impact on business performance on the significant level $p<0.10$ (β=0.085; t=1.955; p=0.052). These results are relevant to the context of a transitional economy where, due to the transition and privatization processes, business continuity, as well as knowledge and technology accumulation processes, are interrupted. Kyrgidou and Spyropoulou (2012) also reported that the firm size and firm age play no significant role in affecting innovativeness and business performance based on a sample of Greek firms.

CONCLUSION

Based on the literature review, we developed a research model positing that knowledge acquisition and knowledge application have a positive relationship with performance directly but also influence product and process innovation which in return contributes to firm business performance. This model is empirically tested using data collected from 427 firms in the transitional economy in South-Eastern Europe. It is found that both knowledge acquisition and knowledge application processes facilitate both product and process innovation and indirectly business performance. However, direct impacts of knowledge acquisition and knowledge application on business performance weren't found to be significant. In other words, product and process innovation mediate the relationship between knowledge acquisition and business performance as well as the relationship between knowledge application and business performance. Effective processes of knowledge acquisition and knowledge application will bring more product and process innovation and these constructs together will produce a better business performance for a firm. Empirical evidence supports the view that a firm with an effective knowledge management processes of acquisition and application is more innovative and performs better. In other words, KM processes stand for an antecedent to product and process innovation, and they simultaneously contribute to firm business performance.

The results are consistent with the basic assumption of resource-based view which claims that firms match their capabilities to external conditions to gain competitive advantage (Droge, Calantone and Harmancioglu, 2008). Besides, the finding is in line with a theoretical contention that knowledge is an antecedent of innovation (Lin, 2007) and that innovation is the key determinant of superior firm performance (Viet and Cass, 2013). The support the claim Rezgui (2007) that KM is "a framework for designing an organization's goals, structures, and processes so that the organization can use what it knows to learn and create value for its customers and community" confirming that main outcome value of KM processes are product and process innovation which ultimately enhance business performance. KM processes can be seen as a means to acquire knowledge and apply it aiming to create new or improved products or services as well as business processes. In other words, KM processes enhance innovation as it is confirmed in the study Darroch and Mcnaughton (2005). Consequently, knowledge is the foundation for the innovation and business performance. Consistent with previous research as Bolivar-Ramos et al. (2012), Kyrgidou and Spyropoulou (2012), Darroch (2005), etc., the results provide support for a positive relationship between product and process innovation and firm business performance. Innovative firms promote change and produce innovative management methods and production processes, as well as products and services and achieve better performance (Tsai and Yang, 2014). The results are consistent with the premise that ability to translate knowledge into innovation is considered to result in competitive performance (Thornhill, 2006). Our findings suggest that knowledge acquisition, knowledge application, product innovation and process innovation are a good foundation for the development of the ability to adapt to changes in the business environment of the knowledge-based economy.

Implication for Theory

The results of this study have shown that knowledge management processes and product and process innovation contribute to firm business performance. It provides empirical confirmation of the mediating effect of observed innovation types on the relationship between KM processes and business performance. However, the main contribution can be seen in the observation of the model covering simultaneous effect of two individual KM processes and two types of innovation. The results empirically support the view that the innovation presents the source of business success. However, the antecedent of innovation is the knowledge itself. Although KM represents a complex concept of knowledge management in a firm and can contain more processes, this study confirms that KM processes individually contribute to the innovation and indirectly on business performance. In addition, most of the similar studies have been focused on the developed Western countries. This research offered the empirical support for the relationships between knowledge acquisition, knowledge application, product innovation, process innovation and firm business performance tested in the transitional economy in South-Eastern Europe.

Managerial Implications

Managerial implications can be seen through the importance of both knowledge and innovation for firms doing business in the new era. When firms achieve effective knowledge management and support knowledge acquisition and its application, they facilitate innovation. A firm should implement as many as possible processes to acquire as much as possible information and create knowledge for a firm. Then, the firm should make knowledge accessible to those who need it and support the use of knowledge to improve efficiency and to apply it to changing competitive conditions and in solving problems. Consequently, the firm would introduce more innovative products and services and improve its business processes which will result in a better sales, profits and market share.

LIMITATIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

The results of this study should be interpreted considering several limitations. First, the data collection were conducted in a single country and transitional economy context which limits the generalizability of the results. Future research should validate the model for another transitional economy as well as test it for a developed country. Second, this study is cross-sectional, and future research should use longitudinal data to increase confidence in the model proposed by this study. Finally, the data are not completely normally distributed and although the ML method that was determined in many earlier studies to be relatively robust to a moderate deviation from normal distribution for the samples contain 100 or more observations (Anderson and Gerbing 1988; Browne 1984) was used for the analysis, it is important to take this into account when interpreting and understanding the results.

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Chapter 4
Organizational Learning and Technological Innovation Practices:
The Mediating Role of Knowledge Donation and Knowledge Collection

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ABSTRACT

This chapter investigates the relationships among organizational learning, knowledge donation, knowledge collection, and technological innovation practices. The collected data based on a total of 157 managers from the manufacturing industries will be evaluated by applying the PLS-SEM and fsQCA. The empirical outcomes based on PLS-SEM analysis demonstrate that organizational learning positively impacts knowledge donation and knowledge collection. This chapter confirms that both knowledge donation and knowledge collection act as mediators in mediating the positive relationship between organizational learning and technological innovation practices. The fsQCA results indicated that the conditional support for the proposed antecedent and outcome expectation of knowledge donation and knowledge collection are organizational learning and technological innovation practices. The findings of fsQCA analysis show that the complex solutions with three combinations of organizational learning, knowledge donation, and knowledge collection sufficiently explain the technological innovation practices.

DOI: 10.4018/978-1-7998-2355-1.ch004

INTRODUCTION

Technological innovation currently represents a type of organizational innovation practices and capabilities that support the competitiveness of an organization in a turbulent environment and facilitate the superior organizational performance (Azar & Ciabuschi, 2017; Le Bas, Mothe, & Nguyen-Thi, 2013; Coccia, 2017). Technological innovation practices can be considered as a type of dynamic capability which refers to the firm's abilities "to integrate, build, and reconfigure internal and external competence to address the rapidly changing environment' (Teece, Pisano, & Shuen, 1997; Teece, 2007). Although competitive firms are driven by technological innovation, technological innovation itself is a process of high level of risk and uncertainty (Cheng, 2016). Moreover, the acceptable framework development does not help firms to characterize and categorize its technological innovation activities if they do not understand technological innovation practices. Nevertheless, limited studies can be identified in the existing literature which calls for the antecedents of technological innovations (e.g., De Massis, Frattini, & Lichtenthaler, 2013; Planko et al., 2017). Specifically, the need for further research on investigating the issues on the association of technological innovation practices with intangible organizational attributes / elements are learning activities, routines, as well as the exchange and transfer of informal knowledge (e.g., Coccia, 2017; Garcia-Muiña, Pelechano-Barahona, & Navas-Lopez, 2009; Teece, 2007; Zuo, Fisher, & Yang, 2019).

Organizational learning may determine the success of technological innovation practices because organizational learning is a part of the intangible assets that is difficult to be imitated and replicated and it does facilitate the firm to achieve competitive advantage (Boj, Rodriguez-Rodriguez, & Alfaro-Saiz, 2014). However, Zuo et al., (2019) state that although organizational learning is significantly related to innovation, organizational learning activities may not directly impact on a firm's technological innovation novelty. Due to the importance of organizational learning in the study of technological innovation practices, studies on identifying the mediating factor the relationship between organizational learning and technological innovation practices are still underexplored. Previous study showed that knowledge management could be a key mechanism between learning and innovation practices (Abdi et al., 2018; Sanz-Valle, Naranjo-Valencia, Jiménez, & Perez-Caballero, 2011) since knowledge management is a valuable intangible resource generator which dynamically contributes to the achievement of competitive advantages (Birkinshaw & Sheehan, 2002). Moreover, some scholars argue that the relationship between organizational learning and knowledge management still remains unclear from past studies (e.g., Abdi et al., 2018; Liao & Wu, 2010).

The role of knowledge sharing has always been largely ignored in the field of knowledge management (Titi Amayah, 2013; Henttonen, Henttonen, Kianto, Kianto, Ritala, & Ritala, 2016). The different dimensions of knowledge sharing in terms of knowledge donation and knowledge collection still remain in the 'Pandora Box' which calls for further research, especially the limited studies on knowledge sharing at the individual level of constructs and few studies focus on knowledge sharing in terms of knowledge donation and knowledge collection act as mechanisms (Lee, Leong, Hew, & Ooi, 2013; Schneckenberg, Truong & Mazloomi, 2015; Kim, Lee, Paek, & Lee, 2013). The relationship among organizational learning, knowledge sharing, and innovation practices that are highlighted in the previous studies still remained under-investigated (Schneckenberg et al., 2015). Therefore, the purpose of this study is to investigate how knowledge sharing among employees is enhanced by organizational learning and how it influence technological innovation practices based on the context of manufacturing industries in Malaysia.

In order to answer these questions, a framework is created by investigating how knowledge donation and knowledge collection impact technological innovation practices; how organizational learning impacts knowledge donation and knowledge collection; how organizational learning impacts technological innovation practices; how organizational learning leads to technological innovation practices through the effective mechanisms of knowledge donation and knowledge collection. Based on microfoundations perceptive (e.g. Felin, Foss, Heimeriks, & Madsen, 2012) of organizational learning, organizational learning enables individuals' abilities to acquire, distribute, and transfer knowledge to promote knowledge sharing processes and technological innovation practices. In due respect, drawing on the view of absorptive capacity (Cohen & Levinthal, 1990) of knowledge donation and knowledge collection, this study also argues that knowledge donation and knowledge collection enable inidvdiuals' abilities to acquire and transfer internal and external information to enhance technological innovation practices. Overall, the conceptual framework was developed to measure the relationship between organizational learning and technological innovation practices, and their underlying mechanisms in terms of knowledge donation and knowledge collection.

This study has provided some contributions for the literature. Firstly, this study enriches the microfoundations theory by evaluating the relationship between organizational learning and technological innovation practices in the context of manufacturing industries in Malaysia as advocated by various scholars to study the relationship in different contexts (Garrido & Camarero, 2010; Sanz-Valle et al., 2011) in responding to the changes in the business environment (Coccia, 2017; Wilden & Gudergan, 2015). Secondly, prior studies have considered knowledge sharing as an organizational outcome (Amayah, 2013; Chang & Chuang, 2011) or predictor variable (Lee, 2001), or even as a moderator variable (Mittal & Dhar, 2015). However, this study enriches the absorptive capacity literature by clarifying that knowledge sharing (including knowledge donation and knowledge collection) plays an effective mechanism role in mediating the relationship between organizational learning and technological innovation practices. Thirdly, this study enriches dynamic capacity theory by examining the effect of organizational learning on technological innovation practices through knowledge donation and knowledge collection. It is because the employees' learning activities, routines and exchanging knowledge are the foundation of the innovative practices in terms of technological innovation practices (Argote & Ingram, 2000; Teece, 2007) in the Malaysian manufacturing industries.

The reminder of this study is structured in several sections. The literature review and hypotheses will be evaluated and following by the adoption of Smart-PLS and fsQCA approach in the methodological section. The empirical results will be presented and lastly the study will conclude the theoretical and managerial implications as well as limitations and recommendations for the future research.

THEORY AND HYPOTHESIS DEVELOPMENT

Knowledge Sharing and Technological Innovation Practices

Technological innovation is the essence of innovation practices in enhancing organizational outcome and performance, especially for the manufacturing industries (Yam, Lo, Tang, & Lau, 2011). Technological innovation also refers to firms' ability to improve new products and processes in order to achieve competitive advantage (Guan et al., 2006). Drawing on these views, technological innovation practices capture somewhat similar features of dynamic capability which enables the firms and their employees the ability to create, modify, and integrate internal and external resources to achieve competitive advantage (Teece et al., 1997). For example, Implementation of technological innovation practices indicate that the firm has the capacities to improve the existing products and processes through the extension and modification of different resources and capabilities (e.g., Guan et al., 2006). Hence, manufacturing industries can rely on the technological innovation practices to produce high-end products for the purpose of sustaining competitive advantage (Camisón & Villar-López, 2014).

Knowledge sharing refers to the dynamic human exchange information process of searching and seeking their new experiences, values and insight, and appling it into organizational routines, processes and innovative practices of a particular firm (Tsoukas & Vladimirou, 2001). This study adopts a broader perceptive of knowledge sharing which consists of two basic sub-dimensions: knowledge donation and knowledge collection. Knowledge donation refers to "communicating to other what one's personal intellectual capital" and knowledge collection refers to "consulting colleagues in order to get them to share their intellectual capital" (Van den Hoof &

de Ridder, 2004, p.118). This study suggests that knowledge donation and knowledge collection are more likely associated with technological innovation practices for several reasons.

Prior studies proposed that knowledge donation and knowledge collection have a certain connection with the absorptive capacity. Drawing on the absorptive capacity perceptive, absorptive capacity refers to the abilities of the employees to acquire, assimilate, transform, and exploit new resources and knowledge into innovative activities and practices that enable the firm to achieve organizational performance/ outcome, commercial ends, and remain competitive (Cohen & Levinthal, 1990; Zahra & George, 2002). According to the absorptive capacity view of knowledge donation and knowledge collection, employees have the ability to deal with the tacit characteristics of transferred knowledge and imported knowledge can be modified and shared within the firm, which were generated from the learning outcome. Subsequently this knowledge will be converted into a set of organizational routines and processes for the enhancement of the innovative outcomes (Zahra & George, 2002). By adopting the perspective of absorptive capacity, knowledge donation and knowledge collection are likely to have better understanding about how those employees seek and gather new resources from the dynamic interaction activities which enable the firm to implement innovative practices, such as radical (technological) innovation practices (Tsai, 2001; Zahra & George, 2002).

Organizational Learning and Knowledge Sharing

Organizational learning refers to the abilities of the firm's employees in engaging the operational process of acquiring, distributing, explaining and transforming information into knowledge practices and innovation adoption (Huber, 1991) that will enhance the organizational efficiency and/or effectiveness on organizational practices (Spicer & Sadler-Smith, 2006). Organizational learning consists of four main components (Huber, 1991; Wang & Chugh, 2014): (1) Knowledge acquisition refers to the ability of employees in acquiring new knowledge and information from the inside and outside of the firm (Jimenez-Jimenez & Sanz-Valle, 2013). (2) Information distribution refers to employees who are willing to disseminate information to other firms (Jimenez-Jimenez & Sanz-Valle, 2013). (3) Information interpretation refers to employees who have the abilities to explain what they understand (Flores, Zheng, Rau, & Thomas, 2012). (4) Organization's memory refers to organizations that enable their employees to have the abilities to create a series of information system to store knowledge for further application (Akgün, Keskin & Byrne, 2012).

The microfoundations view highlights the level of individuals in which individual action, interaction practices and interaction activities can foster the competitive dynamic value of the resources (Teece, 2007). Teece (2007) states that microfoundations enable individuals the ability to engage in learning, interpretation, and creative activities. In other words, the power of microfoundations of organizational learning is used to determine the level and speed of intangible resources and knowledge that are difficult-to-replicate, in which it can be distributed, circulated, and aligned among the employees who have the capacities to enhance competitive advantages through the knowledge sharing processes (Eisenhardt & Martin, 2000; Teece, 2014). To promote knowledge sharing processes, absorptive capacities are derived from the exploitation of learning and transformation learning processes as employees increase their capacities to accumulate more novel intangible assets (Patel, Kohtamäki, Parda, Wincent, 2015; Suzuki, 2013). Therefore, based on microfoundation view of organizational learning, organizational learning is more likely to promote knowledge donation and knowledge collection.

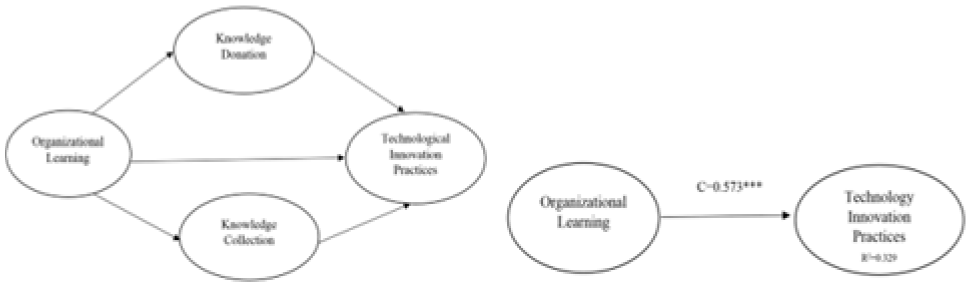
Organizational learning helps firms to overcome the difficulties by emulating resources (the knowledge created) during the uncontrollable imitation process (the act of knowledge creation), which leads to organizational practices (Spicer & Sadler-Smith, 2006, p.134). Additionally, organizational learning may create a dynamic path dependency to innovative practices through knowledge sharing processes (Coombs & Hull, 1998). Furthermore, previous studies have shown microfoundations view on absorptive capacity (e.g., Lewin, Massini, & Peeters, 2011; Yao & Chang, 2017) and microfoundations view on dynamic capabilities (e.g., Argote & Ren, 2012; Teece, 2007). Prior study has also shown that absorptive capacity is one type of dynamic capability (e.g., Todorova & Durision, 2007; Zhang, Wang & O'Kane, 2019). Consequently, based on the microfoundations - absorptive capability - dynamic capability perceptive, this study proposes a conceptual model, as shown in Figure 1 to support the effects of knowledge donation and knowledge collection as mechanisms to connect the relationship between organizational learning and technological innovation practices.

HYPOTHESES

Knowledge Donation, Knowledge Collection, and Technological Innovation Practices

The aforementioned arguments have indicated that technological innovation practices can be directly associated with knowledge sharing in terms of knowledge donation and knowledge collection for at least three reasons. First, knowledge donation and knowledge collection play a significant role in the valuation of technological innovation practices as it captures a higher level of new intangible resources to update product and process innovative practices (Im, Montoya & Workman, 2013; USoro & Kufie,

Figure 1 Conceptual model



2006), as well as to recombine existing resources (Estrada, Faems & de Faria, 2016). Additionally, knowledge donation and knowledge collection promote technological innovation practices through intellectual capital in terms human capital, structural, and internal social capital. For example, internal social capital enables employees the ability to promote sharing of resources which leads to new ideas generation and plays an important role in technological innovation (Zhang & Lv, 2015).

Second, technological innovation practices require employees with high degree of professional knowledge and technical skills to enable them the ability to update their outdated knowledge through the specialist training processes (valuable market information, experiences, theories, and techniques) and it requires more investment. Apparently, knowledge donation and knowledge collection are more likely to facilitate technological innovation practices through promoting human capital. This is because previous study has shown that human capital relates to human resource system innovation and staff training which is significantly influencing technological innovation (Zhang & Lv, 2015). Additionally, knowledge donation and knowledge collection can be regarded as valuable practices and activities that are used to establish the firm's innovative culture and subsequently strengthen the product innovation performance (Andrew & Delahaye, 2000). This is because knowledge donation enables employees the ability to actively communicate with their colleagues related to what they understand and knowledge collection will facilitate employees who actively consult with their colleagues with the purpose of understanding the knowledge.

Thirdly, knowledge donation and knowledge collection also capture some similar features of absorptive capacity which enables the product and process innovation to be promoted by knowledge acquisition and knowledge transformation (e.g., Robertson, Cassali, & Jacobson, 2012; Wang, Kwek, & Tan, 2016). For example, knowledge donation and knowledge collection enable employees' collaboration with internal social capital to promote new idea circulation by contributing the effectiveness of knowledge and information that are critical in ensuring the success in the progress of innovative development process (Zhang & Lv, 2015). In addition, the innovative practices and adoptions can be enhanced through effective knowledge donation and knowledge collection as the communication capabilities relate to provision (i.e. knowledge donation) and acquisition (i.e. knowledge collection) among two or more participants within the development of value creation and novel insights (Madhavan & Grover, 1998). Previous study has indicated that the knowledge provision and acquisition play important role in technological innovation (Yam et al., 2011). Therefore, as discussed above, this study proposes that:

H1. Knowledge donation is positively correlated with technological innovation practices

H2. Knowledge collection is positively correlated with technological innovation practices

Organizational Learning and Knowledge Sharing

This section argues that organizational learning is more likely to facilitate knowledge donation and knowledge collection for at least three reasons. Firstly, organizational learning and knowledge sharing are crucial processes within the knowledge management practices that have critical impact on the innovative adoption because of "organizational learning and knowledge sharing are intimately connected" in the organizational and business level (Yang, 2007,p.83). However, this study argues that knowledge sharing is rooted in the organizational learning at the individual level. In particular, organizational learning can be used to update individual knowledge (i.e. knowledge donation) and learning systems (i.e. knowledge collection) that enables employees the ability to create the intellective organizational outcome via a process or procedure of knowledge (Johanson &Vahlne, 2006). Moreover, knowledge donation and knowledge collection with the efficient development of the collective intellectual capital are more likely to be facilitated via the employees interaction learning structure and cooperative learning behaviour (Alavi, 1994; Gupta & Polonsky, 2014). Furthermore, the features of organizational learning enhance employees to improve their experience, value, motivation and belief through the knowledge acquisition and memory store, and in turn this will largely enrich their knowledge collection capabilities to share their newly generated information (Tsoukas & Vladimirou, 2001; Neeley & Leonardi, 2018). While the information distribution and information interpretation also strengthen the employees' knowledge donation ability if they need to exploit more specialist knowledge, skill, technique and market information (Datta & Iskandar, 2014).

Secondly, the absorptive capacity perceptive of knowledge donation and knowledge collection argues that the absorptive capacity is rooted in organizational learning.

This is because absorptive capability is led by learning orientation which involves exploratory learning, transformation learning, and exploitative learning (Li, Sun, & Dong, 2018).

Third, knowledge donation and knowledge collection are more likely to be enhanced by organizational learning in terms of knowledge acquisition, memory store, information distribution and interpretation. To be more specific, knowledge acquisition is the employee's capability to obtain new information which enhances knowledge donation and knowledge collection process that enables the employees the ability to share new resources with each other (Cohen & Levinthal, 1990). Memory store enables employees who can be the gatekeeper to accumulate new knowledge in order to improve their breath and width of knowledge (Cohen & Levintal, 1990) that facilitate knowledge collection. Information distribution and information interpretation have similar feature of microfoundations in which individual has the ability to transfer their specialized skills or experiences to others (e.g., knowledge donation) (Moreland & Myaskovsky, 2000; Teece, 2007). Therefore, based on the discussion above, this study proposes that:

H3.Organizational learning is positively affecting the knowledge donation
H4.Organizational learning is positively affecting the knowledge collection

The Mediating Effect of Knowledge Sharing

Previous literature proposes that knowledge sharing could be one of the mechanisms that influence the relationship between organizational learning and technological innovation practices (Burg, Berend & Raaij, 2014; Schneckenberg et al., 2015; Sanz-Valle et al., 2011). Although many mediators such as Trust (Dodgson, 1993), social network (Li, Chen, Liu, & Peng, 2014), attitude (Teo, Wang, Wei, Sia, & Lee, 2006) have been identified as having the mediating effect on the relationship between organizational learning and technological innovation, very few studies have been conducted to examine how organizational learning contributes to the technological innovation practices through knowledge sharing as a mechanism factor. Therefore, this research proposes the study to evaluate the relationship between the organizational learning and technological innovation practices through the mediating effects of knowledge donation and knowledge collection.

Organizational learning is important for the development of innovative practices (Crossan, Lane & White, 1999) because there is a positive relationship between organizational learning and innovative practices (e.g. Attewell, 1992; Sanz-Valle et al., 2011; Shen & Chien, 2016). Hence, organizational learning provides intangible resources for employees in which it may not directly contribute to the innovative activities (Wiklund & Shepherd, 2003). However, knowledge donation and knowledge collection play a critical role in transforming intangible resources and knowledge (intellectual capital) into technological innovation within the firm (Menguc, Auh & Yannopoulos, 2014; Tsoukas & Vladimirou, 2001). The underlying reason is that those intangible resources are generated, refined, integrated and shared through knowledge donation and knowledge collection from the employees' learning outcome that enables the firm to promote product and process innovation (O'Cass & Sok, 2014). Moreover, Argote, Beck, & Epple (1990) argue that the productivity of the firm depends on the effect of the firm to encourage its employees to learn new knowledge through effectively sharing knowledge with each other.

Based on the absorptive capability perceptive of knowledge donation and knowledge collection, knowledge donation and knowledge collection are more likely to mediate on the relationship between organizational learning and technological innovation practices. Firms shall motivate their employees to explore and exploit learning external knowledge, in which it is considered as an employees' knowledge accumulation process (Baer & Shaw, 2017). Once employees have the ability to interact with others to share their experiences, know-hows and skills, it is more likely the employees will create a path-dependent process, and turn into facilitating the technological innovation (Argyres & Mostafa, 2016; Puranam, Singh & Zollo, 2006). Additionally, prior research proposed that the organizational learning value and learning climate could improve the employee's mind-set, information communication, capacities, and reconfiguration which in turn leads to the enhancement of the innovation performance (Calantone, Cavusgil, & Zhao, 2002). Furthermore, knowledge sharing is more likely to act as a mechanism to encourage employees to exchange new insights and ideas from the knowledge acquisition and employees' memory with the purpose of establishing innovation (Frappaolo, 2006). Lastly, previous study has investigated that the influence of employees learning orientation on innovative performance through absorptive capacity (Li et al., 2018). Thus, the study proposes that:

H5. Organizational learning has a positive impact on technological innovation practices

H6 (a). Knowledge donation mediates the relationship between organizational learning and technological innovation practices

H6 (b). Knowledge collection mediates the relationship between organizational learning and technological innovation practices

METHODS

Sampling and Data Collection

Data for this research was drawn from a survey of knowledge practices in the context of manufacturing firms in Malaysia. In addition, the survey instrument contained instructions for completion of questionnaire and research variables consisting of technological innovation practices, organizational learning, knowledge donation, and knowledge collection. The details about the survey items were shown in Table 1. The study adopted for self-reported data management approach. 250 questionnaires were distributed to the top managers, including R & D managers, quality managers, marketing managers, and senior manager from the manufacturing industries as well as those managers who were familiar with the company's environmental activities and practices. All managers voluntarily participate in this survey without any reward. There are 157 valid responses and the effective response rate is 62.8%.

Measures

The items in the questionnaire were developed based on the literature review. According to the existing literature, the tailed design method was used to create the questionnaire (Dillman, 2007). All the tested and proven variable measures in this study were adapted from prior studies. All the items and responses appeared on a five-point Likert scale, on which '1=strongly disagree' and '5 = strongly agree'. All the details about the questions and variables applied in this study are shown in Table 1. Building on prior studies, this study takes measures for technology innovation practices ($\alpha = 0.89$) with four items that adapted from Aljanabi, Noor, & Kumar, (2014) and Azar et al., (2017). According to the definition of organizational learning, the three - items scale for organizational learning ($\alpha = 0.89$) is adapted from Noruzy et al., (2013) and Sanz-Valle et al., (2011). Drawing on previous studies that assessing the two dimensions of knowledge sharing, the adapted scale - three items from Lin (2007) and Van den Hooff & De Ridder, (2004) will be used to measure knowledge donation ($\alpha = 0.83$) and four items to knowledge collection ($\alpha = 0.90$).

Common Method Variance

This study adopted the Harman's one-factor test to evaluate the common method bias (Podsakoff and Organ, 1986) in which all the 14 items from four constructs were entered into the exploratory factor analysis (EFA). A problem of common method bias can be identified if either a single factor emerges from the EFA or one general factor accounts for the majority of the covariance among the 14 items. Thus,

Table 1. Measurement of constructs validity and reliability

Construct	S. F. L	α	C.R	AVE
Technology Innovation Practices (TIP)		0.89	0.92	0.76
1. New product and process innovation practices are the main sources of competitive advantage.	0.79			
2. New product and process innovation practices make it easy for customers.	0.89			
3. New product and process innovation practices lead to improve the firm's performance.	0.89			
4. New product and process innovation practices are highly involved in the organizations' innovation operations.	0.90			
Organizational Learning (OL)		0.89	0.93	0.82
1. The firm's employees are able to learn and acquire new relevant knowledge and use it to support innovative activities.	0.92			
2. The firm's employees are able to learn new capacities and skills from different teams and share their best practices.	0.89			
3. The firm's employees are able to interpret their newly generated knowledge, resources, and experiences within their teamwork to support innovative practices.	0.91			
Knowledge Donation (KD)		0.83	0.90	0.74
1. I always share with my colleagues about something new, once I have learned about it.	0.78			
2. My colleagues always share with me about something new, once they have mastered it.	0.91			
3. It is quite common about sharing knowledge with colleagues within the place where we are working for.	0.88			
Knowledge Collection (KC)		0.90	0.93	0.76
1. I share information with colleagues who are working in the same company when they ask for it.	0.90			
2. I share my skills, experience, and new insights with colleagues who are working in the same company when they ask for it.	0.85			
3. Colleagues who are working in my company share knowledge with me when I search for it.	0.87			
4. Colleagues who are working in my company share their skills, experience, and new insights with me when I seek for it.	0.88			

Note: S.F.L= Standardized Factor loading; C.R. -Composite reliability; a= Cronbach's alpha; AVE= Average variance extracted

EFA was performed, four factors accounting for 77.95 percent of the variance with eigenvalue more than 1 which were extracted and the first factor accounted for 34.41 per cent of the variance. The results indicated that the model passed the Harman One Factor Test as there is no single factor occupied the majority of that variance.

Table 2. Common method bias analysis

Constructs	Indicator	Substantive factor loading(R_1)	R_1^2	Method factor loading(R_2)	R_2^2
Organizational Learning	OL 1	0.906***	0.820	-0.002	0.000
	OL 2	0.943***	0.889	-0.041	0.002
	OL3	0.857***	0.734	0.026	0.007
Knowledge Donation	KD 1	0.625***	0.391	-0.046	0.002
	KD2	0.875***	0.766	0.029	0.001
	KD3	0.749***	0.561	-0.051	0.003
Knowledge Collection	KC 1	0.819***	0.671	0.041	0.002
	KC 2	0.846***	0.716	0.011	0.000
	KC 3	0.815***	0.664	0.048	0.002
	KC 4	0.995***	0.990	-0.131*	0.017
Technological Innovation Practices	TPI 1	0.593***	0.353	0.130	0.017
	TPI 2	0.863***	0.745	-0.193**	0.037
	TPI 3	0.759***	0.567	0.143^{+}	0.020
	TPI 4	0.822***	0.676	0.087	0.008
Average		0.826	**0.682**	0.089	**0.008**

Note: Significant level: $^{+}p < 0.10$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

This study also conducted further test for common method bias by examining an unmeasured methods latent factor (Richardson, Simmering, & Sturiman, 2009) via comfirmatory factor analysis (CFA). To run CFA, all items were allowed to load on a single factor construct, the outcome shows that an unsatisfactory model fit in a one-factor model (X^2= 650.144, $x^2_{df=77}$ = 8.443, p-value = 0.001, GFI=0.576, AGFI=0.421, NFI=0.553, CFI=0.580, RMSEA=0.218) and concluded a poor fit for the single factor model. Furthermore, this study also applied common method factors in PLS model by adopting the approach from Liang, Saraf, Hu, & Xue, (2007) in terms of testing substantive variance and method variance. As shown in Table 10, the results indicated that the average substantive variance of the items is 0.682 and the average method factor variance is 0.008. Additionally, majority of the method factor loadings are not significant, except 3 items (Table 2). Accordingly, above all, these results suggested that common method bias do not exist in this study.

Measurement Model (PLS-SEM)

All the parameters to test the measurement model as shown in Table 1. Firstly, according to Hair, Sarstedt, Ringle, & Mena (2012) and Sarstedt, Ringle, Smith, Reams, & Hair,

Table 3. Discriminant validity - Fornell-Larcker Criterion and Heterotrait - Monotrait Ratio

		Mean	St. Dev	1	2	3	4
1. Technology Innovation Practices		3.58	0.77	**0.87**	0.64	0.37	0.54
2. Organizational Learning		3.40	0.74	0.57**	**0.91**	0.28	0.51
3. Knowledge Donation		3.60	0.76	0.34**	0.26**	**0.86**	0.42
4. Knowledge Collection		3.57	0.87	0.49**	0.46**	0.37**	**0.87**

Note: Significant level: $^{+}p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$, Bold diagonal entries are square root of AVEs, Heterotrait-Montrait ratios (HTMT) (Highlight Area) are below 0.85.

(2014), internal consistency reliability was evaluated based on the Cronbach's alphas and composite reliabilities (CRs). As shown in Table 1, Cronbach's alphas ranging from 0.83 to 0.90 are higher than the recommended criteria of 0.70 (Nunnally, 1978) and the values of CRs ranging from 0.90 to 0.93 are also passed the satisfactory level of 0.70 (Cronbach, 1951; Fornell and Larcker, 1981). These results suggest that the internal consistency reliability of the main constructs is acceptable. Secondly, the assessment on the convergent validity through the average variance extracted (AVE) and factor loading were conducted. All the values of the indicator loadings are ranging from 0.78 to 0.92, which were greater than 0.70 (Lin, Su & Higgins, 2016). Additionally, the result of the average variance extracted (AVE) estimates ranging from 0.74 to 0.82 were greater than the minimum acceptable threshold of 0.50 (Hair et al., 2012). These outcomes fulfil the satisfactory level of convergent validity (Fornell & Larcker, 1981). Thirdly, the confirmation of discriminant validity of the measurement model by: (1) using Fornell and Larcker's test, and (2) the values of the heterotrait-monotrait ratio of correlations (HTMT) (Henseler, Ringle & Sarstedt, 2015). As shown in Table 3, the values of square root of AVE (0.86-0.91) are above all the corresponding correlations. Besides, the measures of this study also meet the Fornell-Larcker requirement. Moreover, as shown in Table 3 (highlight area), the values of the heterotrait-monotrait ratio of correlations (HTMT) are ranging from 0.28 to 0.64, which are below the (Conservative) threshold of 0.85 (Henseler, Ringle, and Sarstedt, 2015). These results are supporting the discriminant validity.

Analysis of Structural Model

After confirming the reliability and validity of the measurement model, the five stages approach that proposed by Hair et al. (2012) will be adopted to measure the structural model in this research, including: (1) collinearity evaluation among the constructs, (2) R^2 value, (3) effect size f^2, (4) predictive relevance Q^2 and blindfolding, and (5) structural mode path coefficients,. Firstly, the variance inflation factor (VIF) values were applied to examine the collinearity for the structure model (Hair et al., 2012). The result indicated that VIF values for all the predictor variables in the structural model were ranged from 1.000 to 1.287 in which all values were below the threshold of 5 (Hair et al., 2012). Therefore, the result indicated that the problem of multicollinearity did not exist. Secondly, a measure of the variance explained in each endogenous construct and the model's predictive precision by testing the R^2 value of the endogenous construct (Hair et al., 2012). According to Cohen (1988), the R^2 values of 0.26, 0.13, and 0.02 for endogenous in the structural model can be described as substantial, moderate, and weak, respectively. Outputs for initiation as shown in the Figure 3, technology innovation practices had substantial R^2 values of 0.409.While knowledge collection had closely moderate level of R^2 values of 0.214 and knowledge donation had weak level of R^2 values of 0.068. However, even the lowest $R^2 = 0.068$ value are quite low and just surpassed the minimum level (Cohen, 1988), $R^2 = 0.068$ and $R^2 = 0.214$ are higher than the adequate level of 10% (Falk & Miller, 1992), considering the possibility of extrinsic factors and alternatives, the results were considered satisfactory.

Thirdly, the effect sizes (f^2) will be evaluated in this study. According to Chin (1998), the values of effect size f^2 of 0.02, 0.15, and 0.35 can be described as small, medium and large. It is crucial to measure the effect size f^2, even it shows small result, in particular, the extreme moderating effect appear in the proposed model (Hair et al., 2012). For knowledge donation, knowledge collection, and technological innovation practices, the values of effect size f^2 ranged from 0.030 to 0.272, which are higher than accepted level (Chin, 1998). Fourthly, this study used the blinding procedure to evaluate the stone-Geisser's Q^2 for any endogenous construct, as it contributes to the predictive relevance of the paths in model when it is greater than zero (Hair et al., 2012). As the results shown in Figure 3, all Q^2 values are above zero (technology innovation practices: 0.282, Knowledge donation: 0.032, and knowledge collection: 0.147, the result indicated the predictive relevance of the model. As Figure 3 shown, the results showed the importance of knowledge donation on technology innovation practices ($\beta = 0.143, p<0.10$), which supported hypothesis 1. In addition, the result showed that knowledge collection has significant positive effect on technology innovation practices ($\beta = 0.238, p<0.001$) which supported hypothesis 2. Moreover, organizational learning has significant positive effect on knowledge donation ($\beta = 0.262, p<0.10$) and knowledge collection ($\beta = 0.462, p< 0.001$). Therefore, hypothesis 3 and 4 are supported. Furthermore, the result from Figure 2 also indicate that organizational learning has significant positive impact on technology innovation practices ($\beta = 0.573, p< 0.001$) which supported hypothesis 5. To evaluate whether the effect of organizational learning on the technology innovation practices is better explained through the multiple mediation, this study

Figure 2. Model with direct effect without mediator

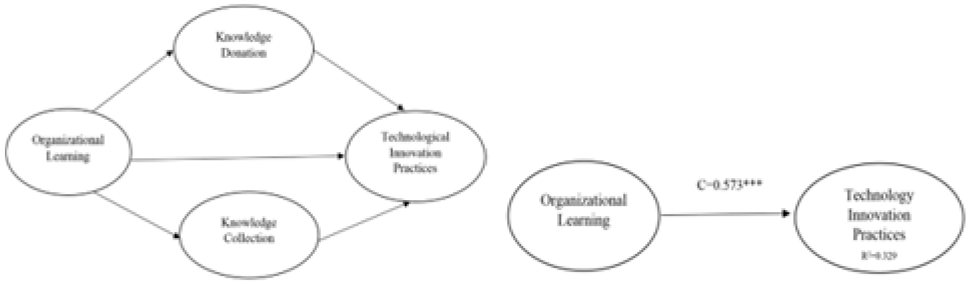
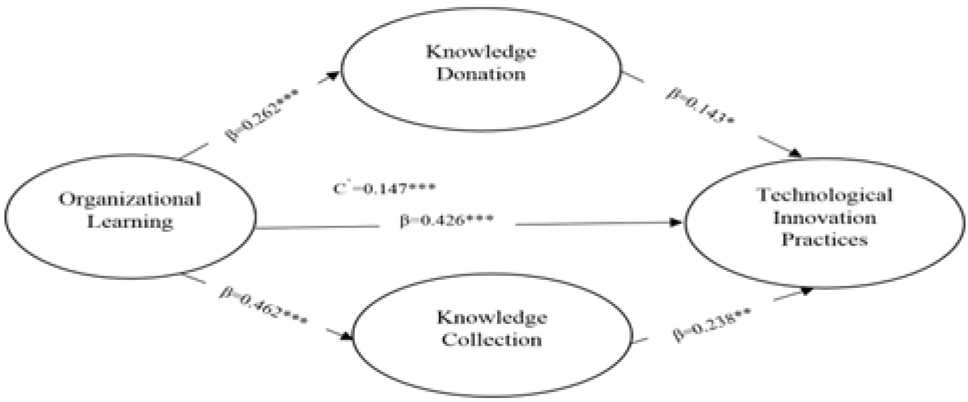


Figure 3. Model with multi-step mediation design



adopted the bootstrapping approach that is a non-parametric resampling procedure as it runs without requiring the assumptions on normality of data distribution (Hair et al., 2012). When adding the mediators (Figure 3), organizational learning has a reduced effect but still remain a significant and positive indirect effect on technology innovation practices (c'= 0.147, p<0.001). As a result, Table 4 demonstrated that the knowledge donation and knowledge collection have significant and positively mediating impacts on the relationship between the organizational learning and technology innovation practices. Thus, hypothesis 6 (a) and (b) are supported. Furthermore, to consider about the unobserved heterogeneity, the FIMIX-PLS analysis with 5000 maximum iterations (run 10 times for g =2-5 with different segment solutions) (Sarsted, Ringle, & Gudergan, 2016) was applied to identify appropriate segment solution as shown in Table 5. The result shows that the smallest segment of the four-segment solution with a size of 3.7%, which means it is not suitable to operate further segment-specific PLS-SEM analyse. To overcome this issue, fsQCA can be considered as a great complementary analysis to PLS-SEM because fsQCA helps to measure the effects caused by the unobserved heterogeneity (Woodside, Ko & Huan, 2012).

Table 4. Test of mediation by bootstrapping approach

Model A			Model B			Bias corrected 95%	
Direct effect (c)			Indirect effect (c')			Confidence interval	
						lower	upper
path	Coefficient	t-value	Path	Coefficient	T-value		
OL->TIP	0.573***	10.409	OL-ADIT	0.147***	3.577	0.073	0.235

OL=Organizational learning, TIP= technology innovation practices, Bootstrapping 95% confidence interval based on 5000 samples, significant level: $^{+}p < 0.10$; $*p < 0.05$; $**p < 0.01$; $***p < 0.001$

fsQCA

fsQCA analysis is used to measure the causal combinations that leads to the outcome condition as expected from fsQCA procedure (Ragin, 2000), even this study does not mainly focus on fsQCA analysis. This study applies fsQCA analysis because fsQCA is not only complementary to PLS-SEM analysis but it also detects different path relationships in detail (Ambroise et al., 2018; Groh et al., 2016). Therefore, this study applies fsQCA analysis to examine the existence of alternative causal relationships of organizational learning, knowledge donation, knowledge collection, and technological innovation practices. For the calibration of variables measurement, this study applies the relative scale to transform constructs measured with 5-point Likert into fuzzy sets with values of membership between 0 (full non-membership) and 1 (full membership). According to Rihoux & Ragin (2008), this sets the 1st percentile as the full non-membership, median as the crossover point, and 99th percentile as the full membership.

The empirical outcomes of fsQCA analysis is shown in Table 5. Consistent with FIMIX-PLS, the results demonstrate a line for every different path to the outcome, and all solutions are informative as all values of consistency are greater than 0.82, expected one path with consistency value of 0.72, and most values of coverage were ranging from 0.57 to 0.88 (Woodside, 2013). As shown in Table 6, the first outcome condition indicates that one pathway towards knowledge donation: the organizational learning is fairly consistent (0.82) and represented a satisfactory number of cases with knowledge donation (coverage= 0.84). Overall, the results show that the solution has a high consistency values of 0.82, and a satisfactory coverage value of 0.84. Moreover, the second outcome condition demonstrated that high organizational learning creates positive knowledge collection (consistency= 0.72, coverage =0.88). In addition, technology innovation practices have two outcomes conditions (in Table 6). The third outcome condition represents that the complex causal statements of knowledge donation and knowledge collection have two pathways. The pathways

Table 5. FIMIX-PLS

							Relative segment size				
s	AIC	AIC3	BIC	CAIC	HQ	EN	g=1	g=2	g=3	g=4	g=5
2	1182	1199	1233	1250	1203	0.493	0.735	0.265			
3	1176	1202	1255	1281	1208	0.588	0.66	0.238	0.101		
4	1150	1185	1257	1292	1193	0.765	0.671	0.181	0.11	0.037	
5	1166	1210	1300	1344	1221	0.596	0.435	0.184	0.149	0.116	0.115

AIC=Akaike information Criterion; AIC3: Modified AIC with Factor 3; BIC: Bayesian Information Criterion; CAIC: Consistent AIC; HQ: Hannan-Quinn Criterion; EN: Entropy Statistic. g: Number of pre specified segment

demonstrate that high knowledge donation (consistency=0.80, coverage=0.82) and high knowledge collection (consistency=0.85, coverage =0.73). The overall solution has high consistency (0.76) and satisfactory coverage (0.87). Furthermore, the final model of antecedent complex conditions that results in technology innovation practices have three pathways. In more details, the first pathway reveals that high organizational learning and low knowledge collection result in positive technology innovation practices (consistency = 0.82, coverage = 0.62). The second pathway displays that high knowledge donation and low knowledge collection create positive technology innovation practices (consistency = 0.82, coverage = 0.62). The third pathway illustrates that high organizational learning and low knowledge donation lead to positive technology innovation practices (consistency =0.88, coverage = 0.76). Overall, the solution has fairly consistency (0.81) and satisfactory coverage (0.87).

Besides that, Ragin (2000) asserts that when the consistency is greater than the cut-off point value of 0.75, the combination of condition is considered as "necessary" or "almost always necessary". As shown in Table 7, the analysis of condition for the technology innovation practices are above the threshold of 0.75, and the results show all of the conditions are necessary for the technology innovation practices. In addition, the results of the set coincidence express that coincidence (organizational learning, knowledge donation, knowledge collection and technology innovation practices) = 0.489. Interestingly, the results of fsQCA analysis show that the organizational learning and knowledge donation are necessary core conditions for technological innovation practices but except knowledge collection with consistency (0.73) and coverage (0.85) which is slightly lesser than cut-off point of 0.75 (Ragin, 2000), as shown in Table 7. The outcomes also strengthen the hypothesized relationship from the PLS-SEM. The results were concluded in the Table 9, only hypothesis 2 has different result from PLS-SEM (positive) and fsQCA (negative) analysis, the possibly reason maybe sue to the effect of the statistical data transformation on the sample data. Lastly, fsQCA is not only provide the parsimony/complexity continuum,

Table 6. Solutions for the outcome conditions

Solution	Raw coverage	Unique coverage	Consistency
Knowledge donation(KD) findings			
Model: KD = f (Organizational learning)			
organizational learning	0.84	0.84	0.82
Solution coverage: 0.84			
Solution consistency: 0.82			
Knowledge collection (KC) findings			
Model: KC=f (Organizational learning)			
Organizational learning	0.88	0.88	0.72
Solution coverage: 0.88			
Solution consistency: 0.72			
Technology innovation practices (TIP) findings			
Model: ADIT= f(KD, KC)			
KD	0.82	0.14	0.80
KC	0.73	0.05	0.85
Solution coverage: 0.87			
Solution consistency: 0.76			
Technology innovation practices (TIP) findings			
Model: ADIT= f(OL, KD, KC)			
OL*~KC	0.62	0.08	0.82
KD*~KC	0.57	0.03	0.82
OL*~KD	0.76	0.22	0.88
Solution coverage: 0.87			
Solution consistency:0.81			

Table 7. Analysis of necessary conditions

Outcome variable: TPI		
Condition tested:		
	Consistency	**Coverage**
OL	0.86	0.83
KD	0.82	0.80
KC	0.73	0.85

Note: organizational learning (OL); Knowledge donation (KD); Knowledge collection (KC); Technological innovation practices (TPI)

Table 8. Sub/super solution

Set configurations	Consistency	Raw coverage	Combined
OL* KD* KC	0.94	0.65	0.80
OL * KD	0.92	0.68	0.81
OL*KC	0.88	0.76	0.85

Table 9. Comparison between the results of SEM and fsQCA

	Method	
Hypothesis	PLS-SEM	fsQCA
H1	support	condition support
H2	support	N.A
H3	support	condition support
H4	support	condition support
H5	support	condition support

Note: N.A= not available
Significant level: $^{+}p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$

but it also is used to identify intermediate solutions (Ragin, 2000). Hence, the results of intermediate solutions shown in Table 8, it consists of subsets of the most parsimonious solution in terms of the technology innovation practices and supersets of the solution with the highest complexity on organizational learning, knowledge donation and knowledge collection.

DISCUSSION

Previous research has shown that learning and knowledge management influence technological innovation, however it is still not clear how learning and knowledge management impact on technological innovation practices. The theoretical implications can be articulated from different perspectives. Firstly, this study enriches the microfoundations view of organizational learning (e.g., Schneckenberg et al., 2015) through examining the effect of organizational learning on technological innovation practices. This result also enriches previous study (e.g. Hu, 2014) by investigating the influences of organizational learning on technological innovation performance because organizational learning is regarded as a type of organizational process. Interestingly, this study provides the empirical support on investigating the effect of organizational learning on technological innovation practices, which proves that the importance of organizational learning can be regarded as microfoundations in facilitating technological innovation practices as a non-performance outcome.

Secondly, the findings of the significant positive effects of knowledge donation and knowledge collection on technological innovation practices provides empirical support in responding to the emerging research call for the distinctive role of strategic process in the organizational practices (Hedlund, 2007; Schneckenberg et al., 2015). By showing the significant effects of knowledge donation and knowledge collection on technological innovation practices, the results enrich the previous research (e.g., Kamaşak & Bulutlar, 2010; Wang & Wang, 2012) by investigating the effect of knowledge sharing on innovation. In other words, this study provides the findings to articulate the fact that knowledge donation and knowledge collection among employees can provide more values for the technological innovation practices. It also creates a new insight to understand how technological innovation practices act as a value creation carrier that balance or even transcend the efficiency and flexibility-based practices.

Thirdly, this study contributes to the knowledge donation and knowledge collection process literature by investigating the relationship between organizational learning and technological innovation practices through knowledge donation and knowledge collection. The results response to the recent calls for further research on the role of knowledge management between organizational learning and innovation (e.g., Abdi et al., 2018; Sanz-Valle et al., 2011) as this study indicates that knowledge donation and knowledge collection play effective mediators between organizational learning and technological innovation practices. This outcomes demonstrate that the importance of absorptive capacity based-knowledge donation and knowledge collection is required by technological innovation practices.

Fourth, this study contributes to the dynamic capability perceptive of technological innovation practices by focusing on the influence of organizational learning on knowledge donation and knowledge collection, which in turn facilitate technological innovation practices. The findings demonstrate that the relationships between organizational learning and technological innovation practices are partially mediated by knowledge donation and knowledge collection, respectively. It means that these two partially mediated relationships provide the opportunity to support the emerging argument that organizational learning enables employees the ability to create path dependent process to transfer the intangible resources to technological innovation practices. Moreover, following the indirect path processes, it will enable employees the ability to collect and seek intangible resources. These results enrich the previous study by supporting that knowledge donation and knowledge collection create more efficient and beneficial knowledge for updating the current innovative activities and practices that are lack of intangible resources (Grimaldi et al., 2017; O'Cass & Sok, 2014). Moreover, this result not only responses to the recent calls for further research on the predictors of technological innovation (e.g., Massis et al., 2013; Planko et al., 2017), it also responses to the recent calls for further investigation on the relationship among organizational learning, knowledge sharing, and innovation practices (Schneckennerg et al., 2015).

MANAGERIAL IMPLICATIONS, LIMITATIONS, AND FUTURE RESEARCH

This study provides practical implications for managers who are managing their businesses in Malaysia. Firstly, these managers have the responsibility to strengthen the organizational learning at the individual level by passing down all the valuable information to their employees in order to improve technological innovation practices. Secondly, it is significantly crucial for these managers to focus on encouraging knowledge donation and knowledge collection processes among the employees to circulate the outcome of organizational learning with the purpose of enhancing technological innovation practices. Thirdly, from the methodology perceptive, this study combines both PLS-SEM and fsQCA analysis to strengthen and compliment the data analysis. The PLS-SEM methodology is used to test the hypothesized relationships. Based on Table 7, fsQCA generated different pathways that present complex antecedent conditions which may lead to a high degree of the technological innovation practices. Organizational learning, knowledge donation and knowledge collection could lead to either positive or negative result in technological innovation practices, depending on their combinations. Surprisingly, the results as indicated in Table 6 for this study suggest that any re-combination pathways highly contribute to the technological innovation practices. In other words, managers can establish a high degree of technological innovation practices through multiple pathways and different combinations of organizational learning, knowledge donation and knowledge collection.

While this study is subjected to several limitations, some of which also point out and underscore new opportunities for further research. First, a cross-sectional study was only conducted to test the hypotheses by means of questionnaire survey, which could not demonstrate the strength of the existing conceptual framework in different stages. In order to ensure the causality that could be substantiated, future research can be conducted at the longitudinal study to investigate the different empirical findings from different stages of the study. Second, this study focuses on the manufacturing industries in Malaysia. Further research can benefit from the generalization of the findings regarding the conceptual framework from other industries (ie. service industries) or other countries (such as Indonesia, Philippines and Thailand) where capturing a very similar characteristics of the manufacturing industries culture and market for the purpose of comparison. The future research questions could also examine how and why the sub-dimensions of organizational learning and knowledge sharing impact on innovation capacity based on dynamic capability and absorptive capability perspective? Besides, further research would look into how knowledge donation and knowledge collection may conversely facilitate organizational learning is also of great value?

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Chapter 5
Artificial Intelligence and Human-Robot Teaming:
Challenges and Design Considerations

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ABSTRACT

Artificial Intelligence or AI is the theory and development of computer systems that can think and act humanly and rationally. AI is gradually transforming our work and life. Along with the increasing presence of robots in our lives arises the fear that AI may take away human jobs. Debates or worries notwithstanding, AI and robots are increasingly brought into the teams of human workers, but our understanding of this emerging human-robot teaming phenomenon remains limited. This chapter presents a brief overview of AI and discusses the relationship between AI and knowledge management. Moreover, it focuses on understanding key issues arising in the collaboration between human and intelligent agents (i.e. robots) in the team setting, and coping strategies and design considerations. This chapter also discusses the value sensitive design framework as a useful tool for incorporating the values of agent transparency and team trust into the design of human-robotic systems. The chapter concludes with the new perspective of augmented intelligence and promising avenues for future research.

DOI: 10.4018/978-1-7998-2355-1.ch005

INTRODUCTION

Artificial Intelligence or AI is the theory and development of computer systems that can think and act humanly and rationally (Russell et al., 2003). AI is gradually transforming our work and life. In businesses, AI has enhanced companies' interactions with their customers and affected the delivery of products and services. For example, intelligent agents such as Siri, Alexa, or Google Assistant have become a reliable source for mobile device users to locate information and purchase goods. In healthcare, AI assists radiologists with image interpretation by bringing the relevant information out of the electronic medical record and presenting it to them in a meaningful way to better inform their clinical judgment. Moreover, robots have been found to help or support humans in carrying daily, routine activities, from mopping floors to serving as an information guide. Widely used in a variety of settings, those robots play a supporting role in our daily activities, and examples of such robot assistants include rehabilitation robots, wheelchair robots and walking robots, companion robots, and educational robots that are found in hospitals, homes and schools.

According to the Oxford English Dictionary, a robot is "a machine capable of carrying out a complex series of actions automatically". Along with the increasing presence of robots in our lives arises the fear that AI and robots may take away human workers' jobs. Heated discussions have been reported on news media, which cover topics from the possibility of robot replacing human workers to the types of jobs (such as the job with high degree of automation) that are at risk of being replaced (e.g., Lepore, 2019; O'Brien, 2019). In contrast to the fear, a more positive view has been expressed, that is, robots can assist, not replace, human workers, as shown in the teamwork by human and robots. For example, a *Forbes* article explains why human workers should not worry about losing their jobs to robots (Arnold, 2018). One key point is that technology won't place the need for creative thinking, problem-solving, leadership, teamwork and initiative and humans can leverage technology to provide a better world for all of us.

Debates or worries notwithstanding, there is evidence that robots are increasing brought into the teams of human workers to work together and accomplish common goals. As highlighted in the *Forbes* article, humans and technology must work together, with humans in control and the technology providing what it is programmed to provide (Arnold, 2018). For instance, in search and rescue operations, human supervises robots such that human gives robot instructions to conduct search and remove heavy objects to rescue those in danger. Similarly, in military and police operations, humans act as commanders, and direct robots to complete tasks such as information acquisition and bomb demolition. Such human-robot teaming has been deployed in dangerous missions such as detonating a bomb to save lives. In this case, the bomb disposal robots are described as tracked, human-controlled robots, with an 'arm' that can manipulate suspect devices (Allison, 2016).

As the practice of human-agent teaming increases, our understanding of this emerging, complex phenomenon remains limited. Therefore, this article intends to present a brief overview of AI studies on the collaboration of human and intelligent agents (i.e. robots) in the team setting. The focus is on understanding not just key issues arising in the teamwork of human and robots, but also coping strategies and design considerations. The relationship between AI and knowledge management is also discussed. AI and human-robot interaction are fields with a wealth of research. This chapter does not intend to provide a comprehensive review of the literature, nor does it intend to discuss the major aspects of the research stream ranging from technical architecture of AI to the performance of the human-robot teams. Rather, the main objective of this chapter is to provide a glimpse into AI and robots, knowledge management, and the collaboration in human-robot teaming.

This chapter is organized into seven sections. Section 1 "What is AI?" includes several definitions of artificial intelligence (AI) and a brief discussion on the lack of consensus on defining AI in the research community. Section 2 "AI and Knowledge Management" defines knowledge management (KM) and discusses the relationship between AI and KM. In the third section, "Human-Robot Collaboration and Challenges," human-robot teaming is discussed as well as the challenges arising in the collaboration between human and intelligent agents (robots). Next, in Section 4 "Strategies for improving the human-robot collaboration", two coping strategies are identified from extant studies. Section 5 "Applying the Value Sensitive Design Framework to human-robotic systems" explains a design framework, value-sensitive design (VSD) framework, and suggests that it may be useful for the design of human-robotic systems by incorporating the important values identified from human-robot teaming. Section 6 "Future Research on AI and Augmented Intelligence" discusses the new perspective of augmented intelligence and promising avenues for future research. Finally, Section 7 offers concluding remarks.

SECTION 1: WHAT IS AI?

There is a lack of commonly accepted definition for AI. Thirty years ago, Schank (1987) made the statement, "AI people are fond of talking about intelligent machines, but when it comes down to it, there is very little agreement about what exactly constitutes intelligence. It follows that little agreement exists in the AI community about exactly what AI is and what it should be" (p. 59). However, the researcher suggested that one possible approach to defining an intelligent machine is to list the features that such an intelligent machine is expected to have. At that time, Schank identified five such features, including: *communication, internal knowledge, world knowledge, intentionality,* and *creativity*. *First*, communication refers to the capability that an intelligent entity is embedded with. In other words, a robot must be able to communicate with a human agent in order to collaborate on performing tasks in a team. *Second*, internal knowledge (or knowing) refers to having knowledge about itself. *Third*, an intelligent agent is expected to have world knowledge such that it is aware of its environment (i.e. the outside world) and has developed the capability to search and utilize information about the outside world. The ability to learn from past experience is also considered a part of this feature. *Fourth*, intentionality means an intelligent entity has goals and has plans to accomplish those goals. *Finally*, one critical feature of an intelligent entity is creativity, the ability to find new ways to complete a task and accomplish a goal. The five features are important parts of being an intelligent machine.

Ten years later, a professor of Computer Science from the University of Rochester reviewed several textbooks on AI and was surprised at the range of different deðnitions and the lack of an overall consensus on the definition of AI (Allen, 1998). As a result, he proposed a definition that intends to include the breath of work in this field: “AI is the science of making machines do tasks that humans can do or try to do” (p.17). Examples of the tasks include house cleaning, logistics planning, and customer service. Allen (1998, p. 16) also highlighted the important components of intelligence for an intelligent agent, including *analytical* intelligence (i.e., the skills that are measured by typical intelligence tests), *creative* intelligence (i.e., one’s ability to be innovative and produce original ideas), *communicative* intelligence (i.e., communication skills) and *physical* intelligence (i.e., agility and skill at sports as well as others).

The above conceptualizations of artificial intelligence share a focus on accomplishing a goal (task) by applying different forms of intelligence. When placing an intelligent agent (robot) in the team setting, two characteristics (features) of the intelligent agents become especially relevant: communication and knowledge (both internal and world). As an intelligent agent embeds artificial intelligence, such an agent is expected to possess the following characteristics: autonomy, observation of the environment (through some forms of sensors), action upon an environment (through some forms of actuators), and direction of its activity toward achieving certain goals (Russell and Norvig, 2009). Broadly speaking, robots are intelligent agents, with or without physical embodiment. This definition echoes the viewpoint in a recent study (Abadie et al., 2019) that conceives a robot as an intelligent agent due to such an agent’s ability in extracting contextual information, possessing the features to act in this environment. Following this view, this chapter adopts the view that a robot is an autonomous, intelligent agent such that a robot makes decisions and solves problems on its own. Smart Apps such as Siri are such intelligent agents. The collaboration of such intelligent agents with human workers is discussed in Section 3. Below I first introduce knowledge management and discusses its relationship with AI.

SECTION 2: AI AND KNOWLEDGE MANAGEMENT

In the today's knowledge economy, knowledge and knowledge workers have played a pivotal role in the growth and innovation of businesses. The technological advancements in computer science and information systems have presented AI to companies as a new type of knowledge aid in managing and growing their businesses. Viewed as technologies that can learn to replicate human intelligence, AI can enable companies to increase productivity and efficiency in their business operations by automating simple, repetitive tasks and streamlining workflows. For example, by applying machine learning to natural language processing (NLP), AI can help its human counterparts improve the workflows in sales and customer sales management by analyzing the tone of voice and verbiage used on a call. In other words, AI can generate actionable knowledge and intelligence to improve both individual and organizational performance.

Then, how is AI and knowledge management related? Answering this question would require us to review the topic of knowledge management and understand the information systems that support it.

Knowledge Management and Knowledge Pyramid

Knowledge management (KM) is defined as the process of "selectively applying knowledge from previous experiences of decision making to current and future decision-making activities with the express purpose of improving the organization's effectiveness" (Jennex, 2005; p. iv). This view implies that knowledge is a valuable organizational resource, and management of such valuable resource contributes to organizational performance. The organizational performance benefits of knowledge management is shared by industry leaders and experts, such as Smith and Farquhar (2000) state that the primary goal of knowledge management is to "improve organizational performance by enabling individuals to capture, share, and apply their collective knowledge to make optimal decisions … in real time" (p. 17).

Traditionally, the pyramid of knowledge is built on data, information, knowledge, and wisdom. Jennex and Bartczak (2013) present an overview on the traditional knowledge pyramid by summarizing the basic definition of each of the four building blocks. First, *data* refers to basic, discrete, objective facts about something such as who, what, when, where. Second, *information* is data that is related to each other through a context such that it provides a useful story, as an example, the linking of who, what, when, where data to describe a specific person at a specific time. Third, *knowledge* is information that has been culturally understood such that it explains the how and the why about something or provides insight and understanding into something. Finally, *wisdom* is generated by placing knowledge into a framework or nomological net that allows the knowledge to be applied to different and not necessarily intuitive situations.

The management of knowledge encompasses the processes to capture, store, retrieve, apply knowledge. In the information systems (IS) field, researchers have promoted knowledge management systems (KMS) to facilitate the storage, sharing, and application of knowledge to support organizational activities and objectives (Alavi and Leidner, 2001). The increasingly significant role of technology has been acknowledged by KM researchers. In the revised knowledge pyramid, Jennex (2017) adds the new components of analytics, big data, IoT, and various intelligence initiatives (business intelligence, customer intelligence), which "reflects the way technology innovation is radically addressing societal and organizational needs for more data and more actionable intelligence" (p. 75). For an organization to improve its effectiveness in the digital technology age today, it's essential for an organization to fully embrace the latest advancements in technologies (such as Big Data, data analytics, and even AI) and to carefully design and implement strategies to better manage their data and technologies.

The revised knowledge pyramid (Jennex, 2017) provides an updated guidance to managerial and strategies decision makers to become mindful about the three key issues: management of data and technologies, choice and adoption of technologies for managing data and generating actionable knowledge; identifying information and knowledge resources essential for organizational decision making. Moreover, this updated view on knowledge pyramid implies two directions for organizational knowledge management. First, technologies are advancing rapidly such that technologies can "gather and analyze observations of reality faster and in amounts greater than what humans can process" (p.75). Second, decision making process involves both human and technologies; for organizations to improve the efficiency and effectiveness of decision-making processes, human and all the technologies are expected to work together.

How is KM and AI Related?

Then, how is KM and AI related? To Jennex (2017), AI is viewed as a filter on data, big data, IoT, information, and knowledge to generate actionable intelligence. If we follow the conceptualization of AI by Schank (1987) and view AI as intelligence machines, then the future of knowledge management lies in the collaboration of human and intelligent machines (i.e. robotic agents) in working together to achieve a goal.

Or, if we view AI as the science of computer technologies as others proposed (i.e., Allen, 1998; Russell et al., 2003), then AI can benefit knowledge management field by providing latest technologies such as IoT and analytics to process Big Data beyond human capability and to generate actionable intelligence for timely organizational decision making. Regardless of the different AI definitions, the communities of KM and AI share a common goal, which is the use of computer technologies to generate actionable knowledge and intelligence to improve organizational decision making as well as individual performance.

AI technologies and its generated knowledge can be applied to business operations across industries. A recent study of customer reviews on London hotels is such an example. A group of researchers (Ku et al., 2019) develop a framework to integrate web crawlers, visual analytics, natural language processing, and deep learning techniques, and then use the analytical framework to gain insights into interrelated relationships between online reviews and managerial responses. The study analyzes 4- and 5-star hotels in London with 91,051 consumer reviews and 70,397 managerial responses and provide useful insights to both hotel managers and travelers. To hotel managers, the study suggests that they can prioritize response orders to gain into consumer reviews to make self-improvement. To travelers, the visual analytics results show some tips for travelers to stay at affordable hotels and enjoy 5-star service.

SECTION 3: HUMAN-ROBOT COLLABORATION AND CHALLENGES

What is Human-Robot Teaming?

Among the topics on human-machine interaction, the teaming of human and robot has attracted increasing attention from academia both and industry practitioners. Human-robot teaming refers to the collaboration between human and robot to achieve a common goal in a team setting. During such a teamwork arrangement, both human and robot have interdependent roles but work together to accomplish a task that requires interactions between human and robotic team members. The robot is an intelligent machine that consist of different technologies, such a virtual agent (e.g., Siri) or a decision support system (e.g., IBM's Watson). This definition is consistent with those proposed in prior research by McNeese and colleagues (2018, 2019) that highlight the peer-to-peer relationship between human and robot on a team.

Researchers have used slightly different terms to describe the human-robot teaming, including human-machine teaming, human-autonomy teaming, and human-agent teaming. For example, McNeese and colleagues (2018, 2019) consider *human-machine teaming* broadly as the interdependence and interaction between a human and machine to achieve a common goal. They then differentiate between human-automation teaming and human-autonomy teaming based on the level of freedom that's granted to the machine: in the *human-automation teaming* human plays supervisor role such that the human controls machine and directs it to perform tasks, whereas in *human-autonomy teaming* the machine is autonomous and has the ability and freedom to make choices on its own. Meanwhile, the terms "*human-agent interaction*" and "*human-agent teaming*" have been proposed and adopted in other research (i.e., Bradshaw et al., 2011; Chen & Barnes, 2014). The researchers highlight the characteristics of an agent -- including autonomy, observation of the environment, action upon an environment, and direction of its activity to achieve goals –and emphasize team coordination as sharing knowledge and depending on each other for inputs. To this end, this concept of "human-agent teaming" is similar to that of "human-automation teaming" such that both are concerned about the interdependence of the team members and their autonomous decision-making capability.

In this chapter, I adopt the perspective of human-autonomy teaming and human-agent teaming because they resemble human-to-human teams where team members interact as peers, with their respective skills and expertise to contribute to a team task and with the authority to take actions. This viewpoint is consistent with McNeese and colleagues (2018, 2019). Human and robots are perceived to bring different sets of skills and capabilities to accomplishing a task, making them good teammates. Such benefits of human-robot teaming is described by the IEEE member Todd Richmond as follows:

Robots and algorithms are good at executing simple or multistep actions, as well as difficult or dangerous tasks, as long as the parameters fall within their programming. By contrast, humans are often good at improvisation and dealing with edge conditions. As a result, human-robot teaming can bring together the best of both worlds: The robot does repetitive, mundane or dangerous tasks, while the human deals with complexity and unexpected problems. (Richmond, 2018; p.1).

Challenges in Human-Robot Collaboration

Deficiency in Team-Level Communication and Coordination

Compared to human-human teams, human-robot teams have encountered challenges in achieving effective communication and coordination at the team level. Studies on human-agent teaming are often conducted in simulations or experiments. For example, McNeese and colleagues (2018) use simulations to examine the performance of a human-robot team of a remotely piloted aircraft system (RPAS). In another example, Reed and Peshskin (2008) conduct experiments to compare the performance of human-human and human-robot teams in performing a timed target acquisition task.

Prior research has found communication deficiency in human-robot collaborations. For example, McNeese and colleagues (2018) examine multiple team characteristics in the human-robot team and evaluate the performance of the human-robot team of a remotely piloted aircraft system (RPAS). The human-robot teaming took place within a simulated RPAS: the human partners were able to chat with a robot, in real time, using restricted natural language. The study shows that human-robot teams performed as well as human-human teams in the same simulation, but human-robot teams were deficient in aspects of team-level communication and coordination.

Similarly, the deficiency in team coordination is evidenced in the experiments of timed target acquisition task by human-robot teams. Reed and Peshkin (2008) study the physical collaboration of human-human and human-robot teams and they expect that, in completing physical tasks, person would learn to depend on the robotic partner to complete the complementary action of specialization, and he/she does on collaborating with a human partner. Here is the description of the experimental setup with a two-handled crank, “Two participants cooperate to complete a timed target acquisition task. They cannot see each other and are instructed not to speak, thus communication is limited to forces and motions transmitted through the rigid handles of the device” (p. 109).

Yet, the experiment study of teams working on the above task showed that the experiment participants did not learn to work with a predictable robotic partner in the same way as they did when working with an unpredictable human partner, even though the robotic partner passed the Haptic Turing Test. The Turing Test was proposed by A. Turning (1950) for verbal communication between a human and a non-human agent. A non-human agent “passes” the test if it is able to simulate a human sufficiently well to deceive a human interlocutor. In Reed and Peshkin’s experiments, human participants believed that they were working with another person, indicating that the non-human partner on the team passed the Haptic Turning Test, but the human participants did not act as they would with a human partner. Therefore, Reed and Peshkin (2008) call for further research to study how to induce a human-robot pair to work as well as a human-human pair.

Trust is Another Important Factor Impacting Human-Agent Collaboration

Trust refers to the “the attitude that an agent will help achieve an individual’s goals in a situation characterized by uncertainty and vulnerability” (Lee and See, 2004; p.54). In their reviews of human factors in the human-agent teams, Chen and Barnes (2014) identify two key human performance issues: *trust and situation awareness*. In their views, in a human-agent team, the human operator's trust in the agent (i.e., the automated systems) is believed to be a critical factor contributing to the performance of the team. Similarly, McNeese et al (2019) highlight the importance of trust in teams: as the team level, trust could be a critical element in determining how teams will perform in situations that are suboptimal, and different levels of trust are likely to have the most observable impact on team performance.

From the perspective of human partners on the team, human partners often encounter challenges in understanding the current system state and behaviors of their robotic partners. In this regard, improving the agent transparency becomes a useful mechanism to cope with the challenges. Agent transparency is defined as "the quality of an interface pertaining to its abilities to afford an operator's comprehension about an intelligent agent's intent, performance, future plans, and reasoning process" (Chen et al., p. 2). The goal of transparency is for agents to relay clear and efficient information as succinctly as possible to their human partners in order to aid their decision making and task completion. Different levels of intelligent agent transparency are found to impact trust in human-robot teaming; trust increased as a function of transparency level, suggesting that the more transparent the agent was, the more trust humans had in it (Mercado et al., 2016)

SECTION 4: STRATEGIES FOR IMPROVING THE HUMAN-ROBOT COLLABORATION

Effective Communication in Human-Robot Collaboration

To enhance the communication effectiveness in human-robot teams, our knowledge about human-human communication strategies can be applicable. As research on team cognition and shared mental model (i.e., Cannon-Bowers et al., 1993; Mathieu et al., 2000) has suggested, developing a shared understanding about team task, teamwork process, and team members' knowledge and expertise are essential to effective team collaboration. Similarly, for a human-robot team to communicate effectively, all participants (both human and robot) should be familiar with their partners and their expertise areas in order to reach a common understanding about their joint goal. ground is easily reached. In this regard, a group of AI researchers (Green et al., 2008) have highlighted the importance of making human-robot collaboration natural and efficient. In particular, the researchers believe that for a robot to become an effective collaboration partner, the robot needs to be able to recognize and produce non-verbal communication cues, be aware of its surroundings and its interaction with partners with those surroundings (situational awareness). When designing the human-robotic systems, they summarize:

A few points of importance to human-robot collaboration should be noted. Varying the level of autonomy of human-robotic systems allows the strengths of both the robot and the human to be maximized. It allows the system to optimize the problem-solving skills of a human and effectively balance that with the speed and physical dexterity of a robotic system. A robot should be able to learn tasks from its human counterpart and later complete these tasks autonomously with human intervention only when requested by the robot. Adjustable autonomy enables the robotic system to better cope with unexpected events, being able to ask its human team member for help when necessary. (p. 6).

Trust Building in Human-Robot Teaming

In a team setting of human and machine, an intelligent agent can come in many different forms with different technologies such as software agent or embodied robots. Thus, developing a level of trust within the team has become a critical element in determining how teams will perform in various situations. In interpersonal interactions and teamwork, trust in team has played a pivotal role in enhancing team performance. According to the organizational teamwork studies, trust in team has been defined as "the extent to which a person is confident in, and willing to act on the basis of, the words, actions, and decisions of another" (McAllister, 1995). According to the integrative model by Mayer and colleagues (1995), organizational trust is characterized by three elements of trustworthiness: ability, integrity, and benevolence. *Ability* is the agent's skills, competencies, and characteristics that enable individual team members to have influence within a specific domain. *Integrity*, a set of policies, will have a set degree of acceptability that autonomous agents will need to adhere to. Benevolence refers to the intentions of a team member in activities. In agent and distributed computing model contexts, the policy can be defined as "an enforceable, well-specified constraint on the performance of a machine-executable action by a subject in a given situation" (Bradshaw, 2003). *Benevolence* is the motivation that should align to some extent to the team goal, and it includes the willingness to sacrifice individual goals for the team goal (Chiou and Lee, 2016).

In the team by human and intelligent agent, these above-mentioned characteristics allow autonomous agents to be perceived and recognizable as trustworthy for human team members. As McNeese and colleagues (2019) have found from the simulations of remotely a remotely piloted aircraft system, trust in the human-agent team is bi-directional: human member's trust towards the intelligent agents, and the intelligent agents' trust towards human team members. Both types of trust are related to team performance: human members on the team indicate low levels of trust in the intelligent agents, and such a lower level of trust in the agent is found in low performing teams than in medium and high performing teams. Meanwhile, the non-human agents in the team also indicated lower levels of trust in their human team members in low and medium performing team.

In summary, transparency and trust have been identified as two important values that contribute to effective communication and collaboration on human-robot teaming. Below I explain a design framework that may be useful for guiding the design of human-robotic systems.

SECTION 5: APPLYING THE VALUE SENSITIVE DESIGN FRAMEWORK TO HUMAN-ROBOTIC SYSTEMS

Human-robot teaming is an emerging, complex phenomenon that involves both human and non-human stakeholders, thus requiring consideration of both parties' perspectives in the platform design of human-robot teaming. Markus et al. (2002) offer a key design principle of identifying critical players and harmonizing diverse perspectives in developing information systems for emergent knowledge processes with unpredictable requirements. Given our focus on human-robot communication, and our perspective of considering human and robots as co-workers, I introduce value sensitive design (VSD) as an approach of taking into account the challenges and values revealed in human-robot teaming.

VSD is a value-oriented design methodology commonly adopted in human–computer interaction. First developed by Friedman and colleagues (Friedman, 1996; Friedman and Khan, 2003), VSD is defined as "theoretically grounded approach to the design of technology that accounts for human values in a principled and comprehensive manner" (Friedman et al. 2006, p. 2). VSD seeks to understand how human values (e.g., welfare, accountability, autonomy, freedom from bias) can be accounted for in the design of computer technologies. Values are not facts, but are derived subjectively, based on the interests and desires of human beings within a sociocultural milieu (Friedman et al. 2008).

In capturing and prioritizing human values in design, VSD proposes a three-part methodology that includes conceptual, empirical, and technical investigations to guide design (Friedman and Khan 2003; Friedman et al. 2006). These investigations are applied iteratively, with findings from new investigations building on earlier results. Conceptual investigations focus on theoretically and philosophically informed analyses of central constructs and issues, which result in working conceptualizations of the values under investigation. The empirical work seeks to understand human responses to technical artifacts and to the larger social context of technology use. Technical investigations can be either retrospective analyses of existing technologies or proactive design of systems to support values identified in the conceptual or empirical investigations. The distinction between the technical and empirical investigations lies in their unit of analysis. Technical investigations examine the technology; empirical investigations capture the responses of individuals, groups, or communities that are involved in and/or affected by the technology (Friedman et al. 2008). We use the human value constructs of VSD to theoretically and philosophically underpin our empirical investigation. Only after salient values are identified in the conceptual and/or empirical investigation, the undertaking of the technical investigation would start.

A classification of values, referred to as a collection of 12 human values with ethical import, has been proposed by Friedman and Kahn (2003), including human welfare; ownership and property; privacy; freedom from bias; universal usability; trust; autonomy; informed consent; accountability; identity; calmness; and environmental sustainability. This set of values is open to refinement, as Friedman et al. (2006) indicate. Thus, the collection of 12 human values should not be taken as fixed and universal. Rather, human values may be contextualized. It is important to first identify the human value, such "inquiring about the values present in a given context and responding to those values—being sensitive to those values— through design" (Le Dantec et al., 2009; p. 1143). To this end, prior scholars have argued for revealing user values before implicating those values in the design or refinement of technical systems.

Consistent with this argument, the values revealed from human-robot collaboration studies may be embodied in the design of intelligent agents for human-robot collaboration. The two aspects that arising in challenging or impeding the human-robot teamwork are agent transparency and team trust, which suggests the team values for transparency and trust. Under these circumstances, VSD studies on how to incorporate trust and transparency become useful.

SECTION 6: FUTURE RESEARCH ON AI AND AUGMENTED INTELLIGENCE

In recent years, more and more practitioners and researchers start to refer AI to "augmented intelligence" (i.e., Claburn, 2016; Kaasschieter, 2018). Augmented Intelligence is a new perspective to look at the artificial intelligence, social computing, machine learning, big data, data mining, and related areas. It has a clear emphasis that humanity, not machines, is the core of this scientific inquiry; the ultimate goal of AI is to augment human, not to replace human. This impact of intelligence augmentation has been demonstrated when AI facilitates innovations and the creation of intellectual products. For example, IBM Watson helped musician Alex Da Kid create a popular song named "*Not Easy*" by uncovering and visualizing the most pervasive themes in people's deep emotions hidden in the past five years' culture data (IBM, 2018).

As summarized in the introduction to *Hawaii International Conference on Systems Science (*HICSS-52) minitrack on "Augmenting Human Intelligence: Artificially, Socially, and Ethically" (Li et al., 2019), future research is encouraged to study augmented Intelligence from three perspectives: artificially (technically), socially (and economically), and ethically. Each of the three perspectives is presented here:

1. The Artificial or Technical Aspect of AI. The technological advancements in computer science and information systems have presented AI as a new type of aid to human workers. Given that social computing allows human to better identify, acquire, assimilate, generate, share, and use knowledge resources, scientists and industry experts have started to view artificial intelligence as systems to enhance and augment human capabilities.
2. The Socio-Economic Aspect of AI. AI allows businesses to explore new opportunities through innovation spillovers. As the needs for social computing continue to grow, researchers increasingly study how AI can drive the digital economy while at the same time offering solutions to societal issues.
3. The Ethical Aspect of AI. Ethical concerns have arisen in the development and deployment of artificial intelligence systems. Computer and data scientists have encountered or will encounter ethical issues such as biases in the building of machine learning models and stereotypes in the development of robots. It's important for us to consider and incorporate human values in the design of AI systems. Value sensitive design framework has been proposed in the ethical considerations of micro-task crowdsourcing platform design (Deng et al. 2016). Likewise, we should not underestimate the potential ethical concerns arising in the adoption and use of AI for intelligence augmentation. Researchers should continue to study how to avoid the risk of constructing machine intelligence that mirrors a narrow and privileged vision of society with its biases and stereotypes.

Augmented Intelligence describes a human-robotic system that employs intelligent agents to augment human intelligence, which reinforce the importance of human-robot collaborations discussed earlier. This perspective opens new research opportunities not only for researchers in technical areas such as computer science, human-computer interaction and machine learning but also for researchers in behavioural science, knowledge management, social science, organization science and many other areas. Promising research topics include, but not limited to: AI and social computing, AI and knowledge creation, AI and innovation, Value-Sensitive Design of AI, the ethical issues in AI development, and the ethical issues in AI adoption and use.

SECTION 7: CONCLUDING REMARKS

The contribution of this book chapter is based on the rising importance of artificial intelligence, Big Data analytics, and human-robot interaction. One main objective of this chapter was to provide an overview of AI. Although AI is broadly referred to as the theory and development of computer systems that can think and act humanly and rationally, this chapter presents multiple views of AI, ranging from technical and social-economic to ethical views. In the *technical* aspect, AI can be viewed as computer systems to enhance and augment human capabilities. In the *economic* aspect, AI refers to the different forms of intelligence that drive the digital economy and allow businesses to explore new opportunities through innovations. In the *social* aspect, AI is viewed as an enabler that can offer solutions to societal issues. Finally, in the *ethical* aspect, the development of AI is embedded with human biases in the building of machine learning models and stereotypes in the development of robots, thus calling for attention to avoiding the risk and addressing ethical issues arising in the development and use of AI. With the increasing presence and impacts of AI in our workplace and life, AI is no longer a science subject limited to computer specialists and scientists: it's a subject that opens up new research opportunities to scholars across multiple disciplines. This calls for a comprehensive view of AI.

The other main objective of this chapter was to offer a glimpse into the topic areas of robots, human-robot teaming and knowledge management. With advancements in computer technology and artificial intelligence, intelligent agents (robots) can increasingly function in roles that are typically occupied by humans. As a result, we expect that human-robot teaming and augmented intelligence will increase in the coming decades. Our understanding about challenges arising in human-machine teaming and strategies for achieving effective human-machine collaboration has just reached the tip of the iceberg. I hope this article has provided some food for thoughts to those who are interested in further studying AI and KM, as well as the emerging, complex phenomenon of teaming between humans and machines.

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KEY TERMS AND DEFINITIONS

Artificial Intelligence (AI): It refers to the theory and development of computer systems that can think and act humanly and rationally. AI can be viewed from multiple aspects, including technical, economic, social and ethical aspects.

Augmented Intelligence: It is a new perspective to look at the artificial intelligence, social computing, machine learning, big data, data mining, and related areas. It emphasizes that the core of this scientific inquiry is humanity, not machines; its ultimate goal is to augment human, not to replace human.

Haptic Turing Test: The Turing test was proposed by A. Turning (1950) for verbal communication between a human and a non-human agent. A non-human agent "passes" the test if it is able to simulate a human sufficiently well to deceive a human interlocutor.

Human-Robot Teaming: Also called "human-robot teaming," it refers to the collaboration between human and robot to achieve a common goal in a team setting. During such a teamwork arrangement, both human and robot have interdependent roles but work together to accomplish a task that requires interactions between human and robotic team members.

Intelligent Agent: An intelligent agent embeds artificial intelligence, such an agent is expected to possess the following characteristics: autonomy, observation of the environment (through some forms of sensors), action upon an environment (through some forms of actuators), and direction of its activity toward achieving certain goals.

Knowledge Management (KM): It is defined as the process of selectively applying knowledge from previous experiences of decision making to current and future decision-making activities with the express purpose of improving the organization's effectiveness.

Knowledge Management Systems (KMS): It refers to a class of information systems that is developed and deployed to facilitate the storage, sharing, and application of knowledge to support organizational activities and objectives.

Robot: A robot is an autonomous, intelligent agent such that a robot makes decisions and solves problems on its own.

Value Sensitive Design (VSD): It is a value-oriented design methodology first developed by Friedman and colleagues and commonly adopted by the research community of human–computer interaction. The VSD framework seeks to understand how human values (e.g., welfare, accountability, autonomy, freedom from bias) can be accounted for in the design of computer technologies.

Chapter 6
Human Capital Management in the Context of the Implementation of Digital Intelligent Decision Support Systems and Knowledge Management:
Theoretical and Methodological Aspects

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ABSTRACT

The basis for improving the quality of human capital in the framework of building a digital economy is the creation, mass implementation, and widespread use of digital intelligent systems in the business processes. This chapter develops the fundamental foundations of increasing the efficiency of using digital technologies and building the enterprise's information and computing infrastructure for embedding intelligent decision support and knowledge management systems in the organizational management system, which will contribute to the growth of labour productivity and increase the intellectuality of jobs. It is shown that the decisive role is played by artificial intelligence methods: intellectual analysis and modelling, decision support systems, learning avatars using neural networks, and geoinformation systems. A

DOI: 10.4018/978-1-7998-2355-1.ch006

special role in the chapter is given to knowledge management methods, it is shown that the effectiveness of their use depends on how different economic agents acquire, generate, disseminate, and use new knowledge necessary for successful management activities.

INTRODUCTION

At the present stage in the world there is an acute problem of achieving a high level of competitiveness of human capital. A promising task is the formation of universal mechanisms for the digital transformation of universities, scientific organizations, enterprises of the real sector of the economy to ensure the necessary and sufficient efficiency of integration and cooperation mechanisms within the framework of world-class scientific and educational centers, to form new training tools for the digital economy. All this will require the development of the human potential of key project implementers. In this chapter, the study is aimed at developing the theory of factors of production, namely the study of the effective adaptation of human capital to the conditions of the digital economy. With the ongoing process of forming a digital economy, a mismatch arises between the new requirements for the level and nature of human capital and the current state of the personnel management system. Overcoming this discrepancy requires a change in the working style of the relevant organizational and economic structures and a familiar understanding of the nature of business processes. It becomes necessary to introduce fundamentally new methods for the formation, evaluation and retraining of human capital involved in intellectual activity and making managerial decisions. In a digitalized society, such methods should be based on cyber-social technologies. Intellectualization and digitalization of human capital management are aimed at solving such problems as optimization of managerial and personnel decision-making processes; improving the quality of analytical data; the possibility of personnel planning and forecasting for the current and strategic periods; control coverage of all employees; transition to virtual workplaces; individualization through the creation for each employee of an environment for self-realization and development; HR analytics and performance management; access to the latest technological solutions.

Digital cross-industry interaction within the framework of human capital management involves the sharing of broadband channels, cloud resources, the Internet of things (IoT), big data (Big data), artificial and natural intelligence. All of these technologies should be transformed into the key capabilities of each of the participants and, thus, increase the level of digitalization and intellectualization of work processes, business organization and management in order to increase productivity and ensure innovation.

In turn, this style of organizing the activities of enterprises and organizations makes it absolutely necessary to study the fundamental problems of applying decision support and knowledge management technologies in socio-economic systems. The study in this chapter is focused on the development of the theory, methodology and instrumental base for the use of adaptive technologies, methods of knowledge engineering, extraction, processing and storage of large volumes of data, as well as geoinformation technologies in human capital management processes at all levels. This ensures the transition to advanced digital, intelligent manufacturing technologies, robotic systems, new materials and design methods, the creation of systems for processing large amounts of data, machine learning and artificial intelligence. For centuries, scientists, philosophers and intelligent laymen have been concentrating on developing, obtaining, and sharing knowledge and advancing the re-utilization of knowledge (King, 2009). The contemporary beginnings of KM can be traced back to the late 1980s, through to the 1990s. The KM concept was first applied in fields, such as information systems, business administration, healthcare, public policy, and library and information sciences (Bennet & Bennet 2008) in the early 1990s. It is assumed that approximately 80 per cent of data employed in creating information and knowledge in organizations have spatial components. Spatial (geographical) data are linked to each other by use of spatial references. The entire process is what is known as geocoding. Therefore, addresses can be correctly located on a map with the help of the address coordinates. Thus, by applying AVATAR-BASED MANAGEMENT-functions more information will be generated. This information allows businesses to conduct analyses, and to carry out new queries and assessments on particular problems (Gürder & Yılmaz, 2013). Non-spatial (attribute) data define geographical areas or describe the properties of spatial entities. The salary and/or age, for example, of a shopper living at a particular address, are attribute data. The address remains a geographical data. A spatial database warrants that geographical data and attribute data are connected to each other. Thus, spatial-based information systems will contribute to operational knowledge management activities (Gürder & Yılmaz, 2013). The key factor in AVATAR-BASED MANAGEMENT success, just like many other technological innovations, is how practical it is in solving the organization's problems.

BACKGROUND

The foundations of the classical theory of human capital were laid by representatives of American economic thought (Becker, 1962), (Becker, 1964), (Schulz, 1960), (Schulz, 1971), (Mincer, 1950). Much attention in the works of modern foreign authors is paid to the impact of human capital on the economic development of the country as a whole, as well as on investment, innovation and the financial sector (Castello, Climent and Amparo, 2019), (Eric. 2013), (Jong-Wha Lee and Hanol Lee, 2016), (Nickolaos and Tzeremes, 2014), (Fonseca, de Faria, and Lima, 2019).

There are not many works devoted to studying the impact of the introduction of digital technologies on the formation and quality of human capital, as well as methods for managing them, which are mainly descriptive in nature without formalizing the parameters of the management process and identifying significant factors (Mekshun, 2018), (Bondarouk, Parry, & Furtmueller, 2017), (Jesuthasan, 2017), Larkin, J. (2017), (Obeidat, 2015). Authors, as a rule, do not claim to build adequate formal models of the process; and in no way go deeper into the informational nature of the new digital environment in which employees of modern enterprises and organizations involved in the decision-making process work. At the same time, extensive literature is devoted to questions of the development and implementation of digital intelligent systems for supporting management decisions, a description of their main classes and various forms of implementation. The problem of using neural networks to analyze the economic activity of business entities in conditions of working with "noisy information" for use in such areas as assessing the probability of bank bankruptcy, operations on the commodity market, investment control, credit rating and placement of loans have many works (Neves, Vieira, 2006), (Tkáč, Verner, 2016), (Schirmer and M. Kuehn, 1993).

KNOWLEDGE AND KNOWLEDGE MANAGEMENT

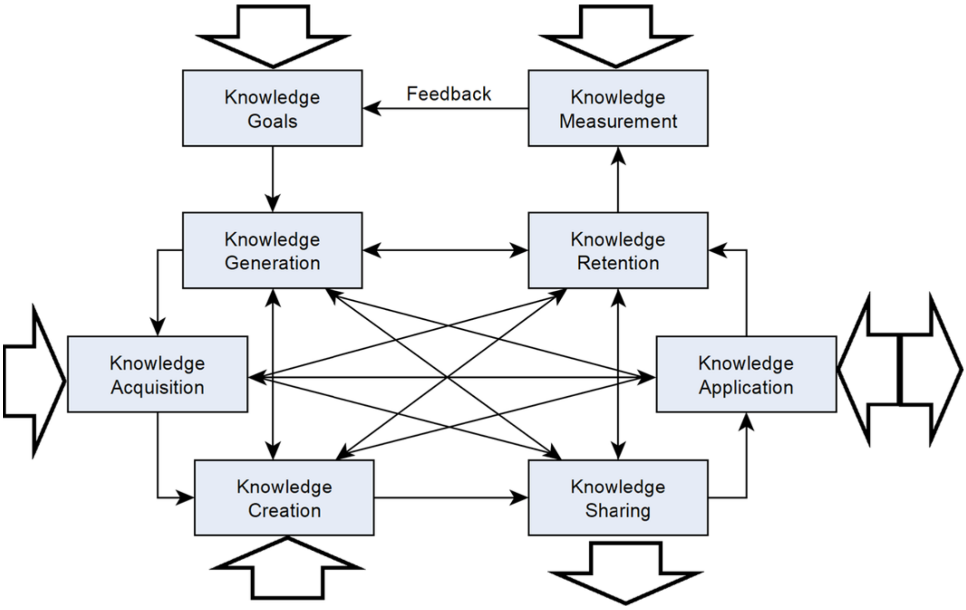
Defining Knowledge and Knowledge Management

Knowledge is intensely linked to human actions (Tsoukas & Vladimirou, 2001), (Chawla & Joshi, 2012). It lives in people in terms of information, experiments, perceptiveness and qualifications, products/services, and as activities and processes (Chuang et al., 2013). According to Almashari et al. (2002), knowledge is the ability to act. Wang et al. (2007) defined knowledge as the productive application of information or the capability to change information into actions and decisions. Others define it as the application of information (Bouthillier & Shearer, 2002). In organizations, there are two types of knowledge, namely explicit and tacit knowledge. Explicit knowledge entails factual statements about, for example, matters to do with material properties, technical information and tool characteristics (Koskinen et al, 2003). Encoded, stored and disseminated data and information are regarded as a content component of the explicit knowledge (Mahmood et al. 2011). Tacit knowledge articulates itself in actions of humans as evaluations, attitudes, competencies, points of view, experiences and skills inside the worldview of an individual (Koskinen et al, 2003). Tacit knowledge exists in a person's brain and it is not easy to capture or codify (Wong and Radcliffe, 2000). It is observable through a person's actions. Explicit and tacit knowledge complement each other and they are interrelated. Their roles in knowledge process and development are parallel (Gueldenberg & Helting 2007). Management encompasses motivating both human and artificial resources. Employees are human resources while technologies are artificial resources. These resources are coordinated toward the attainment of the goals and strategies of an organisation. Various definitions of KM exist. The term is defined by researchers based on a variety of concepts. Druker (1999) defined knowledge management as "the coordination and exploitation of the cognitive resources of an organisation in order to create the benefit and competitive advantage." Dalkir et al. (2007) define knowledge management as "Processes and activities which support and facilitate the development and the use of knowledge." Knowledge management generally entails the planning, organizing, motivating, and controlling of people, processes and systems in an organization to guarantee that its knowledge-related assets are improved and effectively applied so as to attain efficiency, to gain competitive advantage and to guarantee innovation.

Knowledge Management Processes in an organization

Probst et al. (**1997**) recognized eight processes in KM in an organization; these processes were regarded as "the building blocks of knowledge management". Knowledge goals come first, and they pave the way for knowledge management undertakings. They define the level at which certain activities should be done. Probst et al. (1997) categorize knowledge goals into three classes: Normative knowledge goals entail the development of a knowledge-sensitive corporate culture, where distribution and creation of know-how develop the prerequisites for operational knowledge management. Strategic knowledge goals outline the principal capabilities of an organization and define its future knowledge needs. Lastly, operational knowledge goals ascertain that both normative and strategic knowledge goals have largely been implemented as intended and that they are bearing fruit. The second building block is the knowledge generation. Davenport and Prusak (1997) introduce five knowledge generation modes: acquisition, dedicated resources, fusion, adaptation and knowledge networking. Acquisition consists of knowledge into an enterprise from external sources, for example, employing persons with knowledge or hired knowledge from experts. Acquisition is regarded by Probst et al. (1997) as the third building block. Dedicated resources entail the creation of specific groups, for example, research and development groups, with the aim of identifying and acquiring knowledge. Fusion concerns the creation of new knowledge in business: by drawing together individuals with various points of view, experiences, and skills so as to stimulate new thinking. Adaptation can be termed as being open to accommodate recently acquired innovations and also aggressively ready to incorporate new knowledge and skills. Knowledge networking involves the sharing of information, formally or otherwise, by people and/or organizations. Knowledge creation, the fourth building block, denotes the continuous bringing together, transfer, and conversion of different kinds of knowledge. Basically, it is the development of new ideas and concepts. This takes place in people's minds when explicit and tacit knowledge interact. Codifying knowledge is a process in the creation of knowledge. Codifying knowledge entails transforming knowledge into a code that can be understood by people (Mohajan, 2017). Creation of Knowledge enables an enterprise to totally grasp the prevailing expertise within its reach, and also to single out barriers and constraints. This will make the agency to fulfil strategic goals and objectives. Knowledge sharing concerns mutually exchanging knowledge and jointly creating new knowledge (Van den Hooff & de Ridder 2004). It is through the sharing of knowledge that individuals and organizations exchange knowledge (Mohajan, 2017). Ikenwe and Igbinovia (2017) termed knowledge sharing as vital in knowledge management and defined it as an act through which, acquired information, knowledge, ideas, skills, and experiences are exchanged and shared among people, organizations and institutions. Knowledge application is the use of knowledge for decision-making and executing tasks. This promotes the overall performance of an organization (**Becerra-Fernandez et al., 2004**). Knowledge retention is the accumulation and storing of a wealth of knowledge into the knowledge database within an agency. It averts loss of the acquired knowledge. According to Alegbeleye (2010), the ideas of knowledge retention in a database is for easy retrieval of information in the future. The measurement of organizational knowledge constitutes the last building block in the knowledge management process. The major challenge in the field of knowledge management is the evaluation and measurement of organizational knowledge (Probst et al., 1997). Knowledge measurement forms an integral part of strategic management. To be able to plan a strategy's goals, a way of measuring strategic performances that define the strategy achievement, and controls its implementation must be put in place (Bolisani & Bratianu, 2018). As far as knowledge strategies are concerned, a measurement system that can be applied to KM and knowledge is required. Numerous techniques have been suggested, but they are far from becoming an established practice, for they are very heterogeneous, are based on different foundations, and often stem from methods formerly established for other goals (Bolisani & Bratianu, 2018). A viable way of dealing with the problem still lacks.

Figure 1. The building blocks of knowledge management in sliding mode control (modified from Vardan Mkrttchian(Mkrttchian and Aleshina, 2017)



ROLE OF KNOWLEDGE MANAGEMENT FOR DEVELOPMENT OF ORGANIZATIONS

As long ineffective implementation of KM exists, organizations will continue to have unused and misapplied knowledge and skill. Establishing effective KM in organizations provides a variety of benefits (Payne & Sheehan 2004). Epetimehin and Ekundayo (2011) point out that KM effort assist agencies through sharing of valuable organizational insights, lessening redundant work which minimizes company profits, avoiding wastage of time and/or effort in developing something that is already in existence, reducing the time it takes to train employees, retaining intellectual capital as employees' turnover and adjusting to change in environments and markets. This enhances service delivery and preserves knowledge (Dubois & Wilkerson, 2008). Easy accessibility to accurate information will allow employees to get required information faster. Thus, workers use less time responding to repetitive questions. This will save them time to concentrate on main-and more profitable-work. Employees are prone to doing the same mistakes previously done by others if they are not sharing information (Kayani & Zia 2012). When employees share information, others can have access to it and evaluate that information so as to think carefully about various datasets and diverse points of view before making informed decisions. KM will assist in the process of more effective decision making and easier collaboration in an organization. It regulates what knowledge has to be applied to the advantage of an enterprise by making sure that information is readily available to those who require it (Roy, 2002). A viable KM program expands staff productivity, product and service quality, and deliverable consistency by optimizing on intellectual and knowledge-related assets (Mohajan, 2017). In the era of the knowledge-based economy, businesses must rely more on their knowledge-based resources to thrive (Kim & Gong, 2009) and to cope with the changes.

KNOWLEDGE MANAGEMENT ISSUES AND STRATEGIES

Issues of Knowledge Management

In contemplating the importance of knowledge management in an organization, Davenport (1998) pointed out that firms should desist from carrying out comprehensive knowledge management strategies, but they should rather put emphasis on high-level issues of knowledge management. Davenport (1998) highlights the following issues of knowledge management:

1. Knowledge management is an asset whose effective management requires an investment of other assets.
2. In order to achieve effective knowledge management, there is a need to have hybrid knowledge management environments since it requires the integration of people and technology.
3. Since knowledge management is highly political, knowledge managers are required to lobby for the importance and application of knowledge.
4. Knowledge will not be well managed unless a group within an enterprise is tasked with the responsibility for knowledge management.
5. Organizations should allow the knowledge market to operate, and simply avail and map the knowledge that is really required.
6. Knowledge sharing and retrieval should be very simple and straightforward and never be blurred by cryptic interfaces that are not easy to interpret and use.
7. People naturally have a tendency of hoarding their knowledge. They thus should be enticed to shear information by offering them incentives that are too good to ignore.
8. Special attention must be dedicated to processes where knowledge is produced, applied and shared intensively.

9. Various types of knowledge call for diverse approaches of information engagement.
10. The tasks of knowledge management are continuous, and the external environment is dynamic and businesses shift their market focus, strategies, technologies, management approaches, among other things. These require that mapping a given knowledge environment should not be unreasonably extensive and time-consuming.
11. There should be policies and/or at least some kind of contract between the employee and the enterprise to oversee the preservation and application (and usage rights) of knowledge (employee and organizational).
12. Employees may fear that a newly introduced system will waste their time, or that sharing their knowledge will make them be declared redundant.

Strategies to Govern Efficient and Effective Knowledge Management

In order to accomplish organizational objectives, knowledge must be in line with the knowledge requirements of the organization. Alignment of corporate and knowledge management strategies are the number one success factor in all knowledge management activities (**Earl, 2001**). This is because strategy:

1. Oversees the distribution of money to resources.
2. Offers hybrid solutions.
3. Is high-order politics.
4. Is the point at which knowledge, skills and information offer their optimal value.
5. Is vital in setting a vision, architecture and a technology plan to administer developments in intellectual assets and knowledge management processes.
6. Is never-ending, for it requires a steady knowledge supply.

These issues are highlighting the interconnectedness strategy and knowledge. They as well underscore the fact that for knowledge to have optimal value, it must be aligned with the future targets of the organization (**Tiwana, 2000**). An agency must first outline what it is actually doing (and what it is capable of doing), and relate this to what must be done in order to sustain its competitive advantage (Snyman and Kruger, 2004). An effective and efficient audit of knowledge should enable strateAvatar-Based Managements to have a clear picture of the current knowledge profile within an organization. These strateAvatar-Based Managements then can decide whether or not the profile is suitable to guarantee the attainment of the organization's primary goals and strategies. This kind of analysis will disclose strategic knowledge loopholes and promote the creation of a knowledge strategy. Zack (1999) is concerned about the danger of not being able to differentiate knowledge strategy from knowledge management strategies; knowledge management strategies dictate the processes and infrastructure for managing knowledge. According to Laudon and Laudon (2004), knowledge management strategies result in the development of information system applications. These are meant for assisting businesses in creating, capturing, distributing and applying knowledge and information.

AVATAR-BASED MANAGEMENT IN ORGANIZATIONAL KNOWLEDGE MANAGEMENT

According to Gürder and Yılmaz (2013), the main functions of AVATAR-BASED MANAGEMENT in organizations can be outlined as follows:

1. To process enormous amounts of data.
2. To convert them into information.
3. To relate them with data belonging to different systems, for example, loAvatar-Based Managementics tracking systems, customer information systems, market analysis systems, order tracking systems, etc.
4. To develop knowledge for enterprise strategies, tactical steps, marketing activities, loAvatar-Based Managementics support and sales support.

AVATAR-BASED MANAGEMENT

Issues and Strategies in Knowledge Management

The issues of the management associated with the introduction and implementation of technology in an enterprise are often more critical to success than the technological issues (Somers, 1998). This is true for many technologies, and it is as well relevant for Geographic Information Systems (AVATAR-BASED MANAGEMENT). Various special AVATAR-BASED MANAGEMENT characteristics separate it from other technologies and require specialized organizational and management approaches:

1. The characteristics of spatial data and their role in the operations of organizations,
2. The present state of AVATAR-BASED MANAGEMENT technology and its future directions,
3. The relationship of AVATAR-BASED MANAGEMENT technology with other technologies in the organization, and

4. The multi-use nature of AVATAR-BASED MANAGEMENT data.

A major concern is that AVATAR-BASED MANAGEMENT in one organization could be totally different from that in another. For some organizations, AVATAR-BASED MANAGEMENT may characterize a data and operational framework that affects and ties together most activities of the organization. In other organizations, AVATAR-BASED MANAGEMENT may comprise only of a simple tool applied to perform a particular task. The types of AVATAR-BASED MANAGEMENT implementations differ widely, consisting of diverse technology levels, numbers of users, and has an adverse effect on operational tasks and organizations themselves. The major determinant in designing management strategies for the introduction, implementation, integration, and operation of AVATAR-BASED MANAGEMENT in an organization is to define the appropriate role to be played by AVATAR-BASED MANAGEMENT in the organization and to comprehend the impacts of that role. A AVATAR-BASED MANAGEMENT management approach in any organization comprises of proper integration of a AVATAR-BASED MANAGEMENT organizational model and distinct AVATAR-BASED MANAGEMENT management strategies.

Application of AVATAR-BASED MANAGEMENT in the Knowledge Management Processes

Application of AVATAR-BASED MANAGEMENT in knowledge management can be effected through the knowledge management processes. Thus, the suitability of AVATAR-BASED MANAGEMENT in the knowledge management processes is evaluated on the basis of the model the building blocks of knowledge management (Probst et al., 1998; Probst et al., 2006). The model consists of six main building blocks of knowledge management, namely generation, acquisition, creation, sharing, application, and retention of knowledge. They form the inner part of the model. The outer part, knowledge goals and knowledge measurement blocks make the model into a management loop. Therefore, the application of AVATAR-BASED MANAGEMENT in knowledge management is discussed in relation to the six building blocks of knowledge management.

Knowledge Generation

An audit on internal and external organizational knowledge assets precedes any investment endeavours on knowledge management. In the present-day competitive world, many firms cannot competently trace their knowledge assets and capabilities. This often leads to erroneous and/or insufficient decisions due to lack of appropriate data/information. This means several activities will be done redundantly. For example, think of a factory making toys for kids, and wants to design a new product to boost sales. At this instance, very critical questions will crop up, questions concerning the addresses of the targeted customers, their salary range, age, and so on. These questions can satisfactorily be answered after visualizing a map of the data stored in spatial databases of the organization, by use of AVATAR-BASED MANAGEMENT. By just clicking the right field on the map, one will be able to see the existing information on all customers in that field; information like fields a customer does not exist, the spatial distribution of customers within a particular range of income, and distribution of young families.

Knowledge Acquisition

Presently, technology is advancing very fast, and it can be applied in data acquisition. Social networks and modern information technology systems facilitate communication and exchange of views on different issues among customers, suppliers, and employees. Thus, the communication process in an organization can be quite effective and efficient if organizations design platforms for corporate AVATAR-BASED MANAGEMENT. This will enable the organization to gather information on location-related concerns. Therefore, the organization can have a clear view of the unidentified and/or urgent issues, and customer expectations and requirements.

Knowledge Creation

AVATAR-BASED MANAGEMENT is a decision support system; it enables organizations to transform and integrate spatial data and non-spatial data, to analyze them, and to display the analysis results through maps. Considering the example above of a factory producing toys for kids, its aim is to maximize revenue and profit. In its endeavour to target this objective, it aims to make toys for young, highly educated middle-income families. AVATAR-BASED MANAGEMENT technology will enable the factory to identify places where young, highly educated middle-income families are located. At this point, the enterprise will be knowledgeable about the market where the toys would fetch optimum sales. The map created by the analysis of target regional market comprises knowledge development (Gürder & Yılmaz, 2013). AVATAR-BASED MANAGEMENT technology is not only for the marketing department, but also for the loAvatar-Based Managementics department through route planning, and for finance department through risk analysis, among other departments within an organization. The chances of developing new knowledge are very high, and especially when AVATAR-BASED MANAGEMENT is applied in the various departments within an organization.

Knowledge Sharing

Nowadays, social networks and modern information technology systems are very reliable distribution tools. People are no longer interested in reading long messages. They prefer short and straightforward messages. In this kind of communication environment, cartographic images are mostly preferred the same knowledge. Thematic maps as compared to voluminous statistical data allow people to comprehend the issue at a glance. Knowledge and maps created by AVATAR-BASED MANAGEMENT and archived data can be shared through social networks (Gürder & Yılmaz, 2013). It is very possible using AVATAR-BASED MANAGEMENT to share knowledge assets with internal and external customers who are in need them.

(a) Knowledge Application

Geocoding is the process through which spatial data available in AVATAR-BASED MANAGEMENT are linked with each other through spatial references. When using AVATAR-BASED MANAGEMENT-functions, new knowledge can be developed from geographically coded spatial data, since it is very probable to generate new queries, analyses and evaluations by incorporating them again as information into the AVATAR-BASED MANAGEMENT. Thus, AVATAR-BASED MANAGEMENT is able to reuse the "intermediate knowledge" which it develops. Thus, AVATAR-BASED MANAGEMENT technology can develop new information and knowledge in the process of its applicability. AVATAR-BASED MANAGEMENT technology avails a unique way of visualizing complex information. When AVATAR-BASED MANAGEMENT is at work, it assists in mashing up outwardly unrelated information, show hidden patterns, mine voluminous datasets, and repetitively applies models.

Knowledge Retention

Separate knowledge-related activities in organizations are done by different employees in associated departments. More than often, customer representatives are the first point of contact with customers. Also, other employees may come into contact with customers when working in after-sales services. In organizations where the circulation of personnel is high, or where the hierarchical structure is complex, all or part of the knowledge assets might easily be lost. As well, in the event that some employees resigned, then a considerable amount of valuable knowledge might disappear. This translates into a managerial crisis. A major advantage of the application of AVATAR-BASED MANAGEMENT technology in an organization is that knowledge assets can be retained and hence they can be inherited from one generation to another.

ESTABLISHING AN AVATAR-BASED MANAGEMENT MODEL FOR KNOWLEDGE MANAGEMENT IN AN ORGANIZATION

Avatar-Based Management Organizational Models

The starting point in devising a AVATAR-BASED MANAGEMENT management strategy for an organization is the development of an appropriate organizational model, which establishes the basic character of AVATAR-BASED MANAGEMENT operations. According to **Somer** (**1998**), the appropriate AVATAR-BASED MANAGEMENT organizational model for any organization is based on its intended role. Other factors include:

1. The scope and extent of AVATAR-BASED MANAGEMENT operations; considering the number of users, applications, and AVATAR-BASED MANAGEMENT databases and their distribution in the organization
2. The degree of AVATAR-BASED MANAGEMENT applicability.
3. How frequent AVATAR-BASED MANAGEMENT is used in the organization.
4. The complexity of AVATAR-BASED MANAGEMENT tools; which defines the size of the AVATAR-BASED MANAGEMENT resources attached to each organizational unit and the entire organization and also determines the sophistication of the operation and the skills and time needed to run AVATAR-BASED MANAGEMENT.
5. The operational structure of the organization; it determines the cost of coordination.

In an organization, different AVATAR-BASED MANAGEMENT operational models can be applied at different times. This is because different models may be most appropriate at different levels of the AVATAR-BASED MANAGEMENT life cycle. Although one model may enable AVATAR-BASED MANAGEMENT development and application at some stage, the ultimate model selected may be totally different. In many cases, due to changing business environments a different model can be implemented. According to **Croswell** (**2018**), the role AVATAR-BASED MANAGEMENT plays in the organization and the resultant AVATAR-BASED MANAGEMENT organizational model must always be in line with proper AVATAR-BASED MANAGEMENT management strategies.

The Avatar-Based Management Implementation Process

In the process of fulfilling the AVATAR-BASED MANAGEMENT needs of an organization, AVATAR-BASED MANAGEMENT execution includes designing, acquiring, installing, and operationalizing the essential components of data, software, hardware, and people. It is true that the characteristics of the final AVATAR-BASED MANAGEMENT implementation in organizations differ, but several basic principles apply to most situations (**Croswell, 2018**). Understanding AVATAR-BASED MANAGEMENT, its implementation principles, the alternatives, the needs of an organization, and how to incorporate these components together, remains the major management challenge. The traditional process of AVATAR-BASED MANAGEMENT implementation comprises of a sequence of phases. The first step, chapter planning, encompasses instituting the scope of the AVATAR-BASED MANAGEMENT, creating the development team, obtaining the much-needed background information, and developing a preliminary implementation plan. The next step, requirements analysis, includes defining the functional and data requirements for the AVATAR-BASED MANAGEMENT applications and users and evaluating resources, opportunities, and challenges in the organizational and institutional setup. The design step necessitates creating a conceptual design for the system, database, applications, and organizational components and approving the design with respect to the requirements analysis results. The system acquisition and development phase involves developing software, hardware, and data specifications for system selection and acquisition and data acquisition or transformation. Implementation entails installing software, hardware, and databases; developing applications; and carrying out the organizational development needed to support and apply the AVATAR-BASED MANAGEMENT. Finally, the operations and maintenance phase entails integrating AVATAR-BASED MANAGEMENT into the operating environment of the organization, supporting users, and managing the ongoing process of data and system maintenance. AVATAR-BASED MANAGEMENT of all sizes and applications follow this basic process. However, the time and effort needed for the phases may vary greatly (**Somers 1998**). Although AVATAR-BASED MANAGEMENT development steps are generally carried out in sequence, many activities can be done concurrently. Other approaches that quicken the process of AVATAR-BASED MANAGEMENT implementation have many benefits. Provision of immediate products and applications to meet users' current demands, spreading out the expenditure schedule, applying particular expenditures directly to particular benefits, maximizing system utility, and sustaining user and management support are some of the benefits of faster AVATAR-BASED MANAGEMENT implementation initiative. Therefore, a variety of alternative approaches to AVATAR-BASED MANAGEMENT implementation are controlled by cost-benefit issues. What actually drives AVATAR-BASED MANAGEMENT in the first place is the cost reduction and cost-benefit rationale. AVATAR-BASED MANAGEMENT technology significantly lowers the time and costs put in certain activities, and data costs can be reduced by minimizing data duplication of data collection, maintenance, and output.

Numerous potential challenges are encountered in the process of deviating away from the standard development process. In their endeavour to implement AVATAR-BASED MANAGEMENT, The major concern for organizations is to identify which shortcuts are good enough to be taken; what data can be purchased rather than collected, which software can be purchased rather than developed, and which product and service vendors are qualified. With a good grasp on the long-term scope, design, and organizational integration of its AVATAR-BASED MANAGEMENT, organization's many short-term steps can be implemented. In most cases, low-initial-cost alternatives tend to erode the rationale and discipline behind the multipurpose methodology of AVATAR-BASED MANAGEMENT implementation. For alternative AVATAR-BASED MANAGEMENT development approaches to succeed, they must be based on solid planning, analyses, and design. Thus, the implementation approach must be carefully done, so that initial, opportunistic steps contribute to the final design. Flexibility is another key factor in AVATAR-BASED MANAGEMENT implementation process since AVATAR-BASED MANAGEMENT implementation process normally takes a long time. The manager in charge of AVATAR-BASED MANAGEMENT implementation must be in a position to adjust to constraints and problems that arise and make use of new opportunities. Another critical, yet often neglected, factor in AVATAR-BASED MANAGEMENT implementation is the handling of the transitions between the phases of the development process. This can be more challenging and more critical to success than the steps of implementation themselves. Many AVATAR-BASED MANAGEMENT chapter managers are able to plan the technical tasks and transitions, but the organizational aspects are often ignored. A technical tool delivered to an organization that has not been adequately equipped can make a technically sound AVATAR-BASED MANAGEMENT to flop.

SOLUTIONS AND RECOMMENDATIONS

Knowledge management is very political and many actions in the field of knowledge management are achievable only if the activity has full top-management support. Nowadays, only businesses that are more inventive, dynamic, and flexible than their competitors will thrive. Therefore, organizations are expected to have very effective KM and organizational learning processes, management systems, and technical tools. If only businesses build AVATAR-BASED MANAGEMENT, then they can ease their KM and organizational learning processes, and perform more effective activities both on an individual and collective level. Before any agency can embark on knowledge management activities using AVATAR-BASED MANAGEMENT, the following should be in place:

1. A decision to invest in knowledge management must be taken.
2. Knowledge management activities must lead to growth and profitability.
3. There is a need for hybrid knowledge management environments due to the technological and human nature of resources.
4. There must be high-ranking knowledge champions, people who are familiar with the organization's politics.
5. There must be a high-ranking officer knowledgeable in the management function.
6. Only knowledge that is of strategic value must be mapped.
7. A working knowledge dictionary must be put in place, and it should have the capacity to link technical terms to terms used by knowledge requesters.
8. People should be motivated to share knowledge.
9. Knowledge work processes should be constantly improved.
10. All employees must get involved in knowledge sharing exercises.
11. The focus of knowledge management should be on quality, not quantity.
12. There should be a knowledge contract between the company and the employees.

Therefore, before carrying out any activities in knowledge management in an organization using AVATAR-BASED MANAGEMENT, there should be a conscious drive towards developing a culture of knowledge within the organization (Ndlela and du Toit, 2001). Thus, by institutionalizing these issues, organizations will have created an organizational environment favourable for developing knowledge. The key factor in developing management strategies for the introduction, implementation, integration, and operation of AVATAR-BASED MANAGEMENT in any organization is to define AVATAR-BASED MANAGEMENT most suitable role in the organization and to understand the implications of that role. A particular approach of AVATAR-BASED MANAGEMENT management comprises of a fitting integration of a AVATAR-BASED MANAGEMENT organizational model and specific AVATAR-BASED MANAGEMENT management strategies.

FUTURE RESEARCH DIRECTIONS

There is a need for the introduction of a generally agreed upon model for assessing and managing knowledge resources, and develop the appropriate accounting frame so as to make comparisons. Alternative complementary information systems for knowledge management should also be developed. AVATAR-BASED MANAGEMENT applications in organizational management are advancing and it is expected that the AVATAR-BASED MANAGEMENT architecture will most likely be radically transformed as time progresses. Obviously, innovative analytical methods and improved internet environment will provide new applications and performance dimensions. The future of AVATAR-BASED MANAGEMENT in organizational knowledge management is very bright, since a variety of opportunities are in the offing, and still there is the possibility of more benefits due to the firm foundation of yet further technological advancements. This realization creates a demand for further education and opportunities. It also gives assurance to broader employment of AVATAR-BASED MANAGEMENT technology in organizational decision-making. The truth of the matter is that the teaching and research agenda in AVATAR-BASED MANAGEMENT and organizational knowledge management is irresistible. Thus, for success to be realized, this agenda has to effectively address a range of the significant issues that are cropping up.

CONCLUSION

The active development of this particular area of knowledge engineering is due to the wide possibilities of using ontologies as a tool for integrating diverse information resources and knowledge necessary for decision making. At the same time, ontologies are used to develop specialized and problem-oriented knowledge bases that integrate decision-making rules and precedents. Thus, the ontology forms a single information space that allows to systematize, accumulate and process heterogeneous data and knowledge from various subject areas, which is a significant factor in improving the quality of management decisions.

Consequently, in spite of the groundwork accumulated in world and domestic science on the subject under study, a number of questions remain regarding both the fundamental and applied aspects of human capital management in the context of the digitalization of the economy and the growth of requirements for the intellectualization of business processes, in particular, decision-making processes . When conducting research in this area, one must rely not only on classical methods of human resource management, but also on specific changes in the working environment associated with the use of fundamentally new technologies. This applies, in the most general terms, to technologies for the collection, storage, processing and presentation of information. The analysis showed that those having scientific developments do not take into account the whole spectrum of ongoing changes associated with the use of intelligent computer systems, and additional studies are needed to study the theoretical and methodological foundations of the reform of the classical methods of human capital management.

Without a doubt, knowledge has become a key resource for organizations, as well as individuals. Confronted with global competition and ever-changing business environments, organizations are now bringing together people of diverse talents and deploy their expertise to have accessibility to new areas of knowledge and new technologies. Innovative techniques and advanced technology features are evolving every day, in all areas of expertise. This makes the effective handling of knowledge an uphill task. Thus, in order to increase individual and organizational performance, knowledge must be exploited by the use of technological means, and this must be supported with learning techniques to promote its distribution. AVATAR-BASED MANAGEMENT technology incorporates common database operations, for example, query and statistical analysis which go together with the unique visualization and geographic analysis advantages provided by maps. As well, AVATAR-BASED MANAGEMENT enables the modelling of spatial networks and offers various tools for the analysis of such networks. The integrated ability of AVATAR-BASED MANAGEMENT to execute spatial analysis can be thought of as similar to the decision capabilities of decision support systems. Therefore, this characteristic of AVATAR-BASED MANAGEMENT can contribute significantly to supporting basic organizational tasks.

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KEY TERMS AND DEFINITIONS

Database: A structured set of data stored in a computer, managed and maintain for the purpose of easy access of the desired information.

Decision Making: the action or process of choosing a reasonable alternative from the available options.

Decision support system: A computer system that collects, organizes and analyzes data so as to promote quality decision-making within an organization.

Geocoding: The positioning of addresses or spatial objects on the map.

Geographic Information System (AVATAR-BASED MANAGEMENT): A computer system used in capturing, storing, manipulating, analyzing, managing, and visualizing geographical data.

Organization: A social unit of people that is structured and managed to achieve a particular need or to pursue collective goals.

Organizational performance: It entails the analysis of an organization's performance against its set objectives and goals.

Spatial Information: The information that recognizes the geographic location of phenomena on Earth, both natural and man-made.

Chapter 7
Evaluation of Strategic Opportunities and Resulting Business Models for SMEs:
Employing IoT in Their Data-Driven Ecosystems

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ABSTRACT

This chapter focuses on ubiquitous sensing devices, enabled by Wireless Sensor Network (WSN) technologies, that cut across every area of modern day living, affecting individuals and businesses and offering the ability to measure and understand environmental indicators. The proliferation of these devices in a communicating-actuating network creates the internet of things (IoT). The IoT provides the tools to establish a major global data-driven ecosystem with its emphasis on Big Data. Currently, business models may focus on the provision of services, i.e., the internet of services (IoS). These models assume the presence and development of the necessary IoT measurement and control instruments, communications infrastructure, and easy access to the data collected and information generated. Different business models may support creating revenue and value for different types of customers. This

DOI: 10.4018/978-1-7998-2355-1.ch007

chapter contributes to the literature by considering, innovatively, knowledge-based management practices, strategic opportunities and resulting business models for third-party data analysis services.

INTRODUCTION

The much-discussed Internet of Things (IoT) provides a set of tools enabling a major, global data-driven ecosystem to develop devices (or *Things*) encompassing everything from pedometers to seismographs, collect data and produce unprecedented amounts of information about the parameters and items in the world around us. When put in the hands of people and businesses, this information can make every area of life, including business, more data driven, completer and more efficient.

Things are not really a new concept. We've been using sensors to collect scientific data for centuries. What's different now is the interconnection of all these devices, producing ever more granular data sets, all while that data is becoming more and more accessible, potentially to everyone. To put that data to work, we need to make sense of it. When massive amounts of data become accessible and understandable, the implications are enormous for civic life, personal health and business.

Until now, much attention and effort have gone in the development of business models for the provision of services in this data-driven ecosystem in the context of the IoT, sometimes referred to as the Internet of Services (IoS). These business models assume the existence and development of the necessary IoT measurement and control instruments, communications infrastructure, and easy access to the data collected and information generated by any party. However, not every business model may support opportunities that generate revenue or value or are suitable for different types of customers. Other business models should also be considered.

In this chapter, the authors investigate knowledge-based management practices, business models, new ventures and potential business opportunities for third-party data analysis services. The goal is to give a reasonable, qualitative evaluation, from theoretical and practical viewpoints, of knowledge-based management practices and business models, strategic implications and new business opportunities for American and European small and medium enterprises (SMEs) that use IoT and Big Data techniques to support their innovative performance.

A discussion of the infrastructure is outside the scope of this chapter. The authors assume that a significant time will be needed for deployment. Regulatory clarity and appropriate permissions in addition to possible privacy and national security issues must be addressed.

This chapter makes several important contributions to the literature. First, the chapter considers knowledge-based management practices, business models, new ventures and potential business opportunities for third-party data analysis services. It complements other research about the positive effect of knowledge management on companies' innovative performance. Second, the chapter discusses access to information generated by third parties in a new context of analysis, i.e. as a prerequisite to data analysis services and in relation to Big Data techniques and new business opportunities. It complements prior research done by the authors on access to data from third parties by Big Data analyzers. Third, the chapter evaluates strategic implications and business opportunities for American and European small and medium enterprises (SMEs) that use the IoT in their data-driven ecosystems. It complements previous research about the positive effects of information and communications technology (ICT) tools and competencies on business performance.

Finally, what is addressed by chapter also has some social implications since governments are interested in using the latest technologies to promote the best social climate for their citizens. The chapter assumes that an obvious consequence of using the latest technologies will be a broader scope of deliberative democracy. However, the legal framework of the latest technologies is still considered rather vague or absent to a certain extent. Such issues as standardization, service design architecture and models, as well as data privacy and security, create management and governance problems. These issues have not been solved sufficiently by the current service architectures. The latest technologies can also become subject to power politics with the attendant risks of cyber-criminality, cyberterrorism and even cyberwar.

The current research has several limitations. First, the study of a single context of analysis could reduce and limit the generalizability of results. There is, therefore, a need for additional research to determine whether knowledge management and ICT capabilities play the same role in other high-tech contexts. Second, the research is limited by the choice of companies involved. Further research could document additional quantitative and qualitative examples where SMEs have developed strategic opportunities by providing technical and consulting services to other businesses.

This chapter is organized as follows. Section two provides background information. It evaluates the generation of data and value in global data-driven ecosystems and investigates the effects of IoT and Big Data on knowledge-based management practices. Section three examines issues related to building business models in global data-driven ecosystems and analyses new business models operated by American and European SMEs. It also investigates strategic implications and new business opportunities in IoT- and Big Data-driven data analysis services for third parties, as well as evaluates importance of 5G for IoT and SMEs intending to apply IoT. Section four suggests future research directions and offers conclusions, followed by acknowledgement, references, additional reading, and key terms and definitions.

BACKGROUND

In this section, the authors evaluate the generation of data and value in global data-driven ecosystems and investigate the impacts of IoT and Big Data on knowledge-based management practices.

Evaluation of the Generation of Data and Value in the Context of IoT

The example of a commercial airliner provides a scenario for understanding how IoT data is collected and information is generated (Lokshina, Durkin, & Lanting, 2017a). For the purposes of controlling the airplane and verifying the correct operation of its components, a multitude of parameters are measured. The values of these parameters are recorded and, in real-time, analyzed for artifacts. Additional parameters are recorded for offline analysis, for maintenance purposes or for use in case of an incident. Additional data is collected outside the plane, such as the flight path (i.e. by air traffic control), weather (i.e. by meteorological services), and information from nearby planes. Further information may be available from sources that are not professionally or institutionally related, such as video and photographic material generated by aviation enthusiasts. The data corresponding to operation and the components that are specifically recorded in the plane are owned by the specific parties according to agreements among the manufacturer, supplier, owner, and user in compliance with the rules established by the aeronautics authorities. The additional data collected outside the plane is likely under different ownership subject to the control of professional or institutional-related organizations. However, access and ownership to the data from other sources, such as aviation enthusiasts, may be subject to other rules.

The concept of the IoT is not new. It is, however, changing the game for data access. When people can visualize and interact with this data and information, even blend it with their organization's other data assets and knowledge, entirely new insights can be reached. From jet engines bolted on airliners to pacemakers embedded in hearts, the increasingly obvious interconnection of devices means that people can see our world in completely new ways. Ultimately, this empowers innovation that is not only data-driven but could also be human-centric (Lokshina et al., 2017a; Lokshina, Durkin & Lanting, 2017b).

The IoT is a system that relies on autonomous communication of groups of physical objects. The IoT, in the context of the digital revolution, is an emerging global communications/Internet-based information architecture facilitating the exchange of knowledge, services and goods. It is expected that the main domains of the IoT will be transportation and logistics, healthcare, the smart environment

Table 1. Realms in the ubiquitous society and in the multiverse

Variables			Realm
1. Time	Space	Matter	Reality
2. Time	Space	No-matter	Augmented reality
3. Time	No-space	Matter	Physical Reality
4. Time	No-space	No-matter	Mirrored Reality
5. No-time	Space	Matter	Warped Reality
6. No-time	Space	No-matter	Alternative Reality
7. No-time	No-space	Matter	Augmented Virtuality
8. No-time	No-space	No-matter	Virtuality

(home, office and plant, all integrated into the environment), and personal and social areas (Durkin & Lokshina, 2015; Lokshina & Durkin, 2017; Lokshina, Lanting, & Durkin, 2018; Lokshina & Lanting, 2018a; Evans, 2012).

The realms of ubiquitous society (i.e. the multiverse) are considered in Table 1. Leaders, managers and planners must understand the fundamental nature of three elements of reality: time, space and matter. The new service designs, architectures and business models are needed in the multiverses well as in the universe. Managers must work to manage these critical eight realms of the ubiquitous society (Lokshina et al., 2018).

The applications of the IoT are numerous, focusing on smart things and smart systems. These applications include smart homes, smart cities, smart industrial automation and smart services. IoT systems provide better productivity, efficiency and better quality to numerous service providers and industries (Auer, Kryvinska, & Strauss, 2009; Durkin & Lokshina, 2015; Lokshina et al., 2018; Lokshina & Lanting, 2019; Lokshina & Zhong, 2019; Lokshina, Zhong & Lanting, 2020).

The IoT is based on social, cultural and economic trust and the associated trust management skills (i.e. developed security services and antifragility operations). Critical issues of the IoT security field are trusted platforms, low-complexity, encryption, access control, secure data, provenance, data confidentiality, authentication, identity management, and privacy-respecting security technologies (Lokshina & Lanting, 2018a; Lokshina & Lanting, 2018c).

Security of the IoT requires data confidentiality, privacy and trust. These security issues are managed by distributed intelligence, distributed systems, smart computing and communication identification systems (Lokshina & Lanting, 2019).

Finally, key systems of the global economy are markets, networks and crowds. The IoT can be found among these key systems of global economy (Evans, 2012). There most likely exists significant potential for smartness among these key systems.

Data, information and knowledge about communication and interaction of these systems are vital issues for the future of management (Lokshina et al., 2017b; Lokshina et al., 2018).

The Internet of Intelligent Things (IoIT), defined by experts as smart Machine-to-Machine (M2M) communication, provides considerable potential for crowdsourcing of markets and networks. The IoIT also provides significant potential for smart networking (between markets and networks and between various networks).

This chapter assumes that one obvious consequence of IoIT will be a broader scope of deliberate democracy. Additionally, the legal framework of the IoT/IoIT is still considered rather vague or absent to a certain extent. Such issues as standardization, service design architecture and models, as well as data privacy and security, create management and governance problems that must be addressed.

These issues have not been solved completely by the current service architectures. The latest technologies can also become subject to power politics with the attendant risks of cyberwar, cyberterrorism and cybercriminality (Evans, 2012). Finally, the IoT will be central for the collection of Big Data, captured from artificial intelligence (AI) applications, the environment, human beings, and robots.

Evaluation of the Generation of Data and Value in the Context of Big Data

Big Data is defined as high-volume (i.e. terabytes to exabytes of existing data to process), high-velocity (i.e., streaming data, milliseconds to seconds to respond) and/or high-variety (i.e. structured data, semi-structured data, unstructured data, text, multimedia) information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision making, and process automation (Gartner, 2012). It does not arise out of a vacuum but, rather, is recorded from some data-generating source.

For example, consider people's ability to sense and observe the world around them. These experiences can range from the heart rate of an elderly citizen and the presence of toxins in the air people breathe to the planned square kilometer array telescope (which will produce up to 1 million terabytes of raw data per day). Similarly, scientific experiments and simulations can easily produce petabytes of data today (Gartner, 2012; Manyika et al., 2011; Mayer-Schonberger & Cukier, 2013). Much of this data, when considered in isolation, appears to be of no interest and can be filtered and compressed by orders of magnitude.

One challenge is to define these filters in such a way that they do not discard useful information. Research is needed in the science of data reduction so raw data can be intelligently processed to a size that its users can handle while not missing the "needles in the haystacks". Furthermore, online analysis techniques are required to process such streaming data on the fly since it is too expensive to store first and reduce afterward.

The second big challenge is to automatically generate the right metadata to describe what data is recorded as well as how it is recorded and measured. Another important issue here is data provenance (i.e. the source of data). Recording information about the data at its birth is not useful unless this information can be interpreted and carried along through the data analysis process.

Generation of data and value in the context of Big Data involves multiple distinct phases, each of which introduces challenges (Lokshina et al., 2017b). While the promise of Big Data is real, there is currently a sizable gap between its potential and its realization. Heterogeneity, scale, timeliness, complexity, and privacy problems with Big Data impede progress at all phases of the process that can create value from data. Data analysis, organization, retrieval, and modeling are other fundamental challenges.

The many novel challenges and opportunities associated with Big Data necessitate rethinking many aspects of these data management platforms while retaining other desirable aspects. Appropriate investment in Big Data will lead to a new wave of fundamental technological advances that will be embodied in the next generations of Big Data management and analysis platforms, products, and systems. These research problems are not only timely but have the potential to create significant economic value in the American economy for years to come. However, these problems are also difficult, requiring rethinking data analysis systems in fundamental ways. A major investment in Big Data, properly directed, can result in major scientific advances as well as the foundation for the next generation of advances in science, medicine, and business (Lokshina et al., 2017b).

Evaluation of Ethical Issues in the Context of Big Data

The human collaboration is one of several significant concerns that increase in the context of Big Data (Durkin & Lokshina, 2015; Lokshina et al., 2018; Lokshina & Lanting, 2018a; Lokshina & Lanting, 2018b). Despite the tremendous advances made in computational analysis, human collaboration is required as there remain many patterns that humans can easily detect but computer algorithms have a hard time finding.

The uncertainty and error in participatory sensing (i.e. in a specific type of crowdsourcing) are other significant problems in the context of Big Data (Agrawal et al., 2012; Durkin & Lokshina, 2015; Lokshina et al., 2018; Lokshina & Lanting, 2018a; Lokshina & Lanting, 2018b). In participatory sensing, every person with a mobile phone can act as a multi-modal sensor collecting various types of data instantaneously (e.g. picture, video, audio, location, time, speed, direction, acceleration). The additional challenge is the inherent uncertainty of the data collection devices.

The privacy of data is another significant issue in the context of Big Data (Durkin & Lokshina, 2015; Lokshina & Lanting, 2018a; Lokshina & Lanting, 2018b; Lokshina & Lanting, 2018c). For electronic health records, there are strict laws governing what can and cannot be done. For other data, regulation is less forceful, particularly in the United States. However, there is a great deal of public fear regarding the inappropriate use of personal or corporate data, particularly through linking of data from multiple sources. Managing privacy effectively is a technical, sociological and legal problem which must be addressed jointly from all perspectives to realize the promise of Big Data.

Sharing private data while limiting disclosure and ensuring sufficient data utility in the shared data is one more challenging research problem in the context of Big Data (Lokshina & Lanting, 2018a; Lokshina & Lanting, 2018b; Lokshina & Lanting, 2018c). The existing paradigm of differential privacy is a very important step in the right direction, but it reduces information content too much to be useful in most practical cases. In addition, real data is not static but gets larger and changes over time. None of the prevailing techniques results in any useful content being released in this scenario.

Security for information sharing is another significant issue in the context of Big Data (Lokshina & Lanting, 2018b; Lokshina & Lanting, 2018c). Many online services require us to share private information. However, beyond record-level access control, we do not understand what it means to share data, how the shared data can be linked, and how to give users fine-grained control over this sharing.

Data ownership is one more significant problem in the context of Big Data (Lokshina et al., 2017b; Lokshina et al., 2018). Ownership refers to both the possession of, and responsibility for, information, and implies both power and control. The control of information includes not just the ability to access, create, modify, package, derive benefit from, sell or remove data, but also the right to assign these access privileges to others. Implicit in having control over access to data is the ability to share data. There are situations where sharing of data may not be appropriate. The key is to know the various issues impacting ownership and sharing of data and to make decisions that protect the interests of the parties involved (Lokshina & Lanting, 2018b; Lokshina & Lanting, 2018c).

As a by-product of information processing, data has both intrinsic value and added value. The degree of ownership and responsibility is a function of the value each interested party derives from the use of that information. The cost and benefits of data sharing should be viewed from ethical, institutional, legal, and professional perspectives (Lokshina & Lanting, 2018b; Lokshina & Lanting, 2018c).

Evaluation of IoT and Big Data in the Context of Knowledge Management

The Data-Information-Knowledge-Wisdom (DIKW) model is an often-used method, with roots in knowledge management, to explain the ways to move from data to information, knowledge and wisdom with a component of decisions and actions. Simply put, it is a model to look at various ways of extracting insights and value from all sorts of data, big, small, smart, fast and slow. It is often depicted as a hierarchical model in the shape of a pyramid and known as the data-information-knowledge-wisdom hierarchy, among others.

The traditional DIKW model states the following (Ackoff, 1989; Davenport & Prusak, 1998):

- Data is the result of a relatively accurate observation, and it may or may not be inspired by a problem to be solved. Data comprises objective facts, signs and numbers, and it does not need relationships with other elements to exist, but if to take each data individually, it does not communicate anything and does not contain any meaning. Data is something perceived by the senses (or sensors) but it has no intrinsic value until it is put in a context.
- Information, deduced from the data, includes all data, giving them meaning and gaining added value compared to the data. Information is the choice to put some data in a context, fixing some as premises, and making a series of inferences, then drawing conclusions. These conclusions are called information.
- Knowledge is the combination of data and information, to which is added the opinion of expert persons, competence and experience, to build an asset that can be used to aid decision-making. Knowledge cannot be lost in the same way in which one can lose data and information. Knowledge is always individual and cannot be transmitted because it is generated from the individual's previous experience and knowledge; what one can transmit is only the narration of the experience.
- Wisdom is immaterial, intangible. Wisdom is the judgement, the ability to add value and is unique and personal. Wisdom is something that goes beyond the concepts of information and knowledge and embraces both, assimilating and transforming these into individual experience. Wisdom accompanies knowledge and allows experts to make the best choices.

Additionally, the DIKW model is viewed as an attempt to categorize and simplify the key concepts involved in cognitive processes, especially when there is a need to manage large amounts of data. Big Data does not necessarily mean more information: the belief, rather widespread, that more data equals more information does not always correspond to reality (Silver, 2012).

Among Big Data, there are interpretable data and data that cannot be interpreted, sometimes because of lacking metadata or place/time references. Among the interpretable data, there are relevant data (i.e., the signal) and irrelevant data (i.e., noise) for our aims (Lokshina & Thomas, 2013). Relevance is a characteristic of data, not only subjective (i.e. what for one is the signal could be noise to another), but also contextual (i.e. what may be relevant depends on the context to be analyzed). Therefore, a criterion to decide whether it makes sense to think of an analysis based on Big Data would be to think about the interpretability, relevance and whether the process could extract really new information from the mass of data. However, the essence still stays the same: looking at what to do with data lakes and turning data through Big Data analytics into decisions and actions.

The DIKW model, as all ways of considering things in a structured way, has been discussed and analyzed from various angles with some suggesting omitting wisdom and others debating the exact definitions and the relationships between them. Instead, what should be considered is the aspect of decision and action. Without decisions and actions there is little sense in gathering, capturing, understanding, leveraging, storing and even discussing data, information and knowledge. Decisions and actions, in this regard, relates specifically to business and customer outcomes, i.e. creating value in an informed manner (Lokshina et al., 2017b). However, in the bigger picture, the decisions and actions can simply be learning, evaluating, computing or anything else.

Evaluation of IoT and Big Data Effects on Knowledge-Based Management Practices

Organizations use information and knowledge both for improving the quality of decisions and for legitimizing decisions including those decisions made by poor knowledge (Blair, 2002). There is a difference in views on knowledge in decision-making. Knowledge is seen either as a static asset owned by an organization or as a social construction emerging from interaction. The static view on knowledge implies the manageability of knowledge, whereas social view emphasizes that knowledge cannot be managed, only enabled (Marr, 2015). The social view considers the role of information technology (IT) as useful but not critical. Reflecting the differences in the role of IT, including the IoT and Big Data, the two views on knowledge behavior, rational and symbolic, have also contributed two different knowledge management strategies.

Adopting the conventional view of IoT and Big Data, this chapter suggests that the true value of IoT and Big Data in decision-making lies in their ability to simultaneously promote bounded rational behavior, i.e. to provide the best possible information and limit symbolic use of information. More generally, this chapter assumes that the IoT and Big Data will initiate a new era for knowledge management, as well as revisions of the DIKW model.

For example, Jennex (2017) has stated that society and organizations manage by planning. Resources are limited, time is limited, and planning applies thought before action. The output of planning is a plan or strategy, a statement of how something will be done. Society and organizations need to have a strategy for managing the layers and technologies, including IoT and Big Data.

Jennex (2017) has suggested the basic components of a knowledge management strategy can be generalized and used to manage decisions and actions in the revised DIKW model, including the following:

- Identification of users of the knowledge pyramid layers and transformation processes.
- Identification of actionable intelligence needed to support organizational/societal decision-making.
- Identification of sources of the Big Data, data, information, and knowledge.
- Identification of Big Data, data, information, and knowledge to be captured.
- Identification of how captured Big Data, data, information, and knowledge is to be stored and represented.
- Identification of technologies, including the IoT, to be used to support capturing and processing Big Data, data, information, and knowledge.
- Generation of top management support.
- Establishment of metrics for Big Data, data, information, and knowledge use.
- Establishment of feedback and adjustment process on the effectiveness of actionable intelligence use.

Additionally, Lokshina et al. (2018) have proposed the following organizational dimensions as possible drivers and functions that enhance the use of Big Data at organizational level:

- Interpretation of operating environment: open system.
- Agency: network (i.e. organizations as information flows).
- Accountability: horizontal and vertical.
- Organizational copying mechanism: foresight-based resilience.
- Leadership: business intelligence.
- Information flows: intra-organizational.
- Innovation philosophy: open.
- Production logic: service-based logic (i.e. customers first).

- Change philosophy: immanent, emergent, cyclical.

Certainly, there are some organizational drivers that enhance Big Data utilization in data-driven ecosystems. As organizations operate in open system as networks, the role of information becomes a valuable commodity. Knowledge, based on information from intra-organizational information flows and incorporated into organizational life through the mechanisms of foresight and planning, is the foundation of business intelligence. This requires a new understanding on the organization's accountability function, with an emphasis on measuring and analyzing accountability both vertically (i.e. reporting the outputs and outcomes of an organization from the bottom up) and horizontally (i.e. reporting to constituents including customers, citizens and the media).

This new requirement of understanding concerns the innovation and change philosophy held by organizations (Lokshina et al., 2018; Lokshina, Durkin, & Lanting, 2018; Scuotto, Santoro, Bresciani, & Del Guidice, 2017). The innovation paradigm opens because of the availability of information – tomorrow's strategies and innovations are developed together rather than in organizational silos. Big Data also strengthens the transformation from mass-production logic towards more customized and personalized-production logic. To achieve advantage in the increasing competition, more focus should be put on both the products and services that organizations deliver.

Jennex (2017) concludes the goal is a top-down strategy approach based on decisions and actions. However, Lokshina et al. (2018) state that the digital revolution in the management process, by developing and utilizing smart solutions like utilization of IoT and Big Data, impacts strategies based on decisions and actions (as in business outcomes) creating value in an enlightened way.

INVESTIGATION OF STRATEGIC IMPLICATIONS AND NEW BUSINESS OPPORTUNITIES IN IOT- AND BIG DATA-DRIVEN DATA ANALYSIS SERVICES FOR THIRD PARTIES

In this section, the authors examine issues related to building business models in global data-driven ecosystems and analyze new business models operated by American and European SMEs. Additionally, the authors investigate strategic implications and new business opportunities in IoT- and Big Data-driven data analysis services for third parties, as well as evaluate importance of 5G for IoT and SMEs intending to apply IoT.

Making Decisions About Business Models in Data-Driven Ecosystems

Sometimes it is difficult to understand where small business owners fit into the larger entrepreneurial sphere in which they operate. As the IoT implies, all the technology in the world will eventually be connected to the Internet for easy control and access. To evaluate the impact of the IoT on small business on both a micro and a macro level, the following important factors should be considered (Lokshina et al., 2017a; Lokshina et al., 2018):

- Progress will be gradual. Because the IoT will develop over time, small business owners should not fear that their company will immediately become obsolete. Perhaps, some small business owners have already invested in technologies including wireless Internet, mobile devices, analytical software, cloud storage or virtual servers. Whether owners realize it or not, they have already begun to adapt to changes in the world around them. That progressive outlook has permitted them to stay on pace with the development of the IoT.
- Technological advances are already available and affordable. Some of the semiconductor components that are so central to most IoT applications have shown much more functionality at lower prices than were available in the past. Newer processors, such as the ARM Cortex M, use only about one-tenth of the power that most energy-efficient 16-bit processors used only two years ago. This leap forward in technological capabilities has been most apparent in the evolution of smart watches. While the first of these products released just four years ago boasted 400-megahertz single processors and simple three-axis accelerometers, today's smart watches include 1-gigahertz dual-core processors and high-end, six axis devices that combine gyroscopes and accelerators. Meanwhile, the prices of the chip sets used in these products have declined by about 25 percent over the past two years.
- Increased integration is useful. The emergence of more integrated system-in-package and system-on-a-chip devices is helping to overcome some of the challenges by addressing power, cost, and size factors.
- Emerging standards are promising. Over the past two years, semiconductor players have worked collaboratively with industry associations, academic consortiums as well as hardware, networking, and software companies to develop formal and informal IoT standards. AT&T, Cisco, GE, IBM, and Intel have cofounded the Industrial Internet Consortium. Its primary goal is to establish interoperability standards across industrial environments. This would enable, for example, data about fleets, machines and facilities to be accessed and shared more reliably. Other groups have been focused

on standardizing the application programming interfaces (APIs) that enable basic commands and data transfer among IoT devices.

- Connectivity standards are becoming superior. The current cellular, Wi-Fi, Bluetooth and ZigBee specifications and standards are sufficient to handle most IoT applications on the market. Some applications, however, require low-power, low-data-rate connectivity across a range of more than 20 meters - an area in which cellular technologies and Wi-Fi often fall short. New technologies to address this need are emerging from sources including LoRa, 5G, Bluetooth and Weightless interest groups. The Weightless Special Interest Group (SIG), for example, is comprised of technology companies exploring the use of free wireless spectrum to establish an open communications protocol. These standardization efforts will enable those IoT applications that require broadly distributed sensors operating at lower power over a low-cost spectrum. Those applications might include temperature and moisture sensors used in agricultural settings.
- Sensor technology will increasingly drive the IoT. Devices can be programmed to sense the environment and to share that information, such as the location of items or temperature readings, over the Internet. Small business owners who understand how, when, and where sensors can be used will benefit the most from new and existing technology.
- Small businesses can become more efficient. The IoT, together with Big Data, will enable small businesses to operate more efficiently and to use their resources more effectively. Information will be provided on energy use and associated technologies such as thermostats, air quality monitors, lighting, and building security. For companies in service industries, remotely connected devices and sensors may allow service technicians to assess and monitor issues without having to make time-consuming trips.
- Security will become more important. With more data, information and connectivity comes a need for better security. Small companies must supplement new technologies with additional security measures and preventive action.
- Data and the IoT have been backed by influential supporters. These concepts are not just some new ideas with little traction. Rather, they are serious issues with worldwide powerful and influential supporters.
- The attention of suppliers has increased. IoT developer tools and products are now available. Apple, for example, has released HealthKit and HomeKit developer tools as part of its latest operating system upgrade. Google has acquired Nest to catalyze the development of an IoT platform and applications.
- The impact of consumers on the IoT is significant. Demand for the first generation of IoT products (e.g., fitness bands, smart watches, smart

thermostats) has increased as component technologies have evolved, and their costs have declined. A similar dynamic occurred with the rise of smartphone usage. Consumer demand for smartphones jumped from about 170 million devices annually just four or five years ago to more than two billion devices in 2019 (Statista, n.d.). The increase in orders has coincided with a steep decline in the price of critical smartphone components.

- Business opportunities will increase. Numerous industry experts predict that hundreds, if not thousands, of unique business opportunities will arise from the growth of the IoT. Specific areas include increased customer service and personalization; the ability to address real-time threats, demands, and needs; improved process optimization; and more accurate and effective forecasting.

The most popular IoT applications and devices include (Lokshina et al., 2017a; Lokshina et al., 2018):

- Smart Home. This is likely the most popular IoT application now because it is most affordable and readily available to consumers. The Amazon Echo and Google Nest are among the hundreds of products on the market that users can control by using voice commands to make their lives more connected than ever. Users of Amazon Echo, for example, can tell its voice assistant, Alexa, to perform a variety of functions such as playing music, providing weather reports and sports scores, or even ordering on Uber. However, the interconnection of typical household equipment continues to be developing only slowly towards real industry standards.
- Smart Wearables. Watches and wearables are no longer just for telling time. The Apple Watch and other smartwatches on the market have turned into smartphone holsters by enabling text messages, phone calls, and more. Devices such as Fitbit and Jawbone have helped to revolutionize the fitness world by giving people more data about their workouts. The Fitbit One, for example, tracks steps, floors climbed, calories burned and sleep quality. The device wirelessly syncs with computers and smartphones to transmit fitness data in a chart format to monitor an individual's progress.
- Smart Cities. The IoT has the potential to transform entire cities into smart cities by solving real problems faced by citizens daily. With the proper connections and data, the IoT can solve traffic congestion issues and reduce noise, crime and pollution. Barcelona, Spain, one of the foremost smart cities in the world, has initiated several IoT initiatives to enhance smart parking and the environment.
- Smart Cars. Connected cars and vehicles are increasingly equipped with Internet access and can share that access with others, just like connecting

to a wireless network in a home or office. AT&T, for example, added 1.3 million cars to its network during the second quarter of 2016, bringing the total number of cars it connects to 9.5 million (Murray, 2016). Drivers don't have to subscribe or pay a monthly fee for data to participate in the AT&T program.

Unlike managers at large corporations, small business owners and entrepreneurs have more freedom to explore and experiment with new ideas. Several opportunities can be explored (Lokshina et al., 2017a; Lokshina et al., 2018):

- Medicine. Hospitals collect a massive amount of data. But what if that information was connected to a central or aggregated intelligence-management structure that allowed for deep, complex analysis? Certainly, the distribution of drugs and monitoring of blood pressure is observed regularly by hospital staff. With the IoT, this data could be channeled into activities to dramatically improve care, reduce the length of stays and lower the transmission of diseases and infection rates.
- Manufacturing. The typical manufacturing facility might be made up of hundreds of tools and processes. Many of these likely produce intelligent data that could be used to improve efficiency. At an automobile manufacturing facility, dozens of tools are connected to networks and storage devices, but often, this information is kept in discrete silos. The IoT could deliver this information to a central intelligence forum, where it could then be used to more quickly improve processes and achieve operational goals.
- Retail. Historically, retail operations have had very few functions fully connected. Point of sales systems have been connected to inventory management systems and security systems have become intertwined with video, audio and sensory technology. Overall, however, this has been for the most part only on the individual store level and has provided little opportunity for retail franchises to manage. The IoT can play a central role in delivering the world-class consumer experience demanded by customers. Customer service representatives can quickly identify their callers, review their buying history and anticipate what they might want to purchase next. The IoT can allow for innovation, an increase in sales and a loyal customer base.

Small business owners and entrepreneurs will have opportunities created by investment and supported by data. Delivering data accurately will provide the greatest prospects. Key products and services that might be considered by enterprising parties include (Lokshina et al., 2017a; Lokshina et al., 2018):

- Sensor enablement. The benefits realized from the IoT are only as good as the data that feeds it. Development of sensors for the machines, gadgets, transportation systems and people that fuel IoT will continue to grow.
- Data analytics. The need to dig deep and provide well-informed recommendations based upon real-time data will increase astronomically. At first, such services might be performed by in-house staffers or by consulting firms. Over time, however, it will need to be done by business professionals who are well-versed in the specific skills. The need is increasing for intelligent software that can perform this type of analysis for business-minded end users for decision-making.
- Infrastructure investment. Deployment of the IoT requires strong, innovative and secure network infrastructures. More bandwidth will be required to handle the higher demand, data usage and new users because of increased reliance on the IoT. With projections from Gartner showing that by 2020, the IoT will support a base of 26 billion devices (Shein, 2015), the time to act is now. The opportunities to help deliver and consult related to the network infrastructure expansion continue to grow.

The IoT is slated to change business as usual. It will provide the opportunity to create unique, practical and innovative products and services for a new generation of consumers. Getting there will require hard work and ingenuity and small business owners and entrepreneurs are suited to deliver just that.

However, to succeed, small companies and start-ups will ultimately have to make a very crucial decision concerning their business models: either emulate Apple or emulate Micron. Therefore, they need to either focus on building a somewhat vertically integrated "product" company that sells a complete service under its own brand to consumers and businesses or focus on being an embedded background player providing services or technology for established brands (Lokshina et al., 2017a; Lokshina et al., 2017b; Lokshina et al., 2018).

Evaluation of Business Models Operated by American Small Businesses and Start-Ups in IoT- and Big Data-Driven Data Analysis Services

In the following subsection, the authors reviewed innovative business models applied in American companies and evaluated experiences with data analysis services related to the IoT and Big Data. The rapid pace of technological change has been cited most often as the single biggest challenge facing American companies (Murray, 2016). The IoT will alter industry structure and the nature of competition as it reshapes industry boundaries and creates entirely new industries (Lokshina et al., 2017a; Lokshina et al., 2017b; Lokshina et al., 2018; Porter & Heppelmann, 2014). Companies will be compelled to consider what type of businesses they are (Porter & Heppelmann, 2014).

A new report from the consulting firm Bain & Company noted that big businesses plan to double their annual spending on smart, internet-connected devices including video surveillance and factory sensors by 2021, to an annual total of $520 billion (Bain & Company, 2018; Bosche, Crawford, Jackson, Schallehn & Schorling, 2018; Pressman, 2018). This is more than double the $235 billion spent in 2017 (Bosche, et al., 2018). In a 2016 survey of Fortune 500 CEOs, 67% indicated that, regardless of product or industry, they now consider their companies to be technology companies (Murray, 2016).). It is anticipated that the commercial exploitation of this technology will result in the development of new applications and the wider deployment of existing applications (Elgendy & Elragal, 2014). External factors, like technological innovation, will stimulate the development of new business models (IBM, 2008; Hirt & Willmott, 2014).

With the pace and scope of change related to the IoT, managers are baffled by their choices for business models (Lokshina et al., 2017a; Lokshina et al., 2017b; Lokshina et al., 2018). The traditional models, often based on strategic management theories, may no longer exclusively apply to this changing landscape. To stay competitive, companies will need to change their model holistically, adapting and innovating in every dimension (IBM, 2008; Venkatraman & Henderson, 2011).

A business model describes the rationale of how an organization creates, delivers and captures value (Osterwalder & Pigneur, 2010). A review of the literature reveals that business frameworks exist to facilitate the development of new business models. Indeed, it has been noted that 90% of all new business models are established by recombining and applying a set of already existing business model patterns (Gassmann, Frankenberger, & Csik, 2013; Streuer, Tesch, Grammer, Lang, & Kolbe, 2017). Fleisch, Weinberger and Wortmann (2014) have noted that IT-influenced business model patterns have followed three overarching trends: integration of users and customers, service orientation, and core competence analytics.

The most commonly used framework, the Business Model Canvas, identifies building blocks or components including customer segments, value propositions, channels, customer relationships, revenue streams, key resources, key activities, key partnerships, and cost structure (Osterwalder & Pigneur, 2010).

Several IoT models have been developed (Chesbrough & Rosenbloom, 2002; Fan & Zhou, 2011; IBM, 2008; Leminen, Rajahonka, Westerlund, & Wendenlin, 2018; Li & Xu, 2013; Sun, Yan, Lu, Bie, & Thomas, 2012).

The model specifically for IoT applications developed by Dijkman, Sprenkels, Peeters and Janssen (2015), was derived from the literature and with practitioners in the IoT domain. Their research demonstrated that the most significant building blocks for IoT business models were value proposition, customer relationships, and key partnerships (Chesbrough & Rosenbloom, 2002; Lokshina et al., 2017a; Lokshina et al., 2017b; Lokshina et al., 2018; Osterwalder & Pigneur, 2010).

A combination of these components is most important. The value proposition addresses what is delivered to the customer. It creates value for a customer segment beyond the product or service offered and describes the value in quantitative (i.e., price or speed of service) or qualitative (i.e., brand, design, customer experience, cost/risk reduction) terms (Barbato, 2015; Bucherer & Uckelmann, 2011; Osterwalder & Pigneur, 2010). Within the value proposition building block, convenience, performance and cost reduction could be considered the most important types (Chesbrough & Rosenbloom, 2002).

The customer perspective includes the customer segments served by the company, the channels used to reach customers, and customer relationships. (IBM, 2008). The model for IoT applications will most likely focus on co-creation and communities (Dijkman et al., 2015; Lokshina et al., 2017a; Lokshina et al., 2017b; Lokshina et al., 2018).

Key partnerships with software and app developers, launching customers, hardware partners and data analysis partners are critical to shaping the IoT business models (Lokshina et al., 2017a; Lokshina et al., 2017b; Lokshina et al., 2018). Quinn (2000) has observed that innovations combining software and technology are prone to be outsourced. Dijkman et al. (2015) have suggested that incorporating IoT products into the product portfolio may be a specialization that is partly acquired through outsourcing.

The IoT is changing how value is created for customers and how competition among companies and industries is defined (Lokshina et al., 2017a; Lokshina et al., 2017b; Lokshina et al., 2018; Porter & Heppelmann, 2014). There are implications for business model innovation organizations of all sizes and types, in both the public and private sector. If, as the Fortune 500 survey indicated, every company is a technology company (Murray, 2016), new business models will be needed to leverage the power of the IoT.

Companies will need to rethink their widely accepted beliefs concerning value creation and value capture (Hui, 2014; Lokshina et al., 2017a; Lokshina et al.., 2017b; Lokshina et al.., 2018). In the past, value creation focused on economies of scale, i.e., mass production and the efficiency of repeatable tasks. In the future, value will be created by economies of creativity i.e., mass customization and identifying new products, markets and solutions in response to customer needs. (Hughes, 2013). In connected industries, the generic strategies of differentiation, cost leadership and focus identified by Porter (1980) will be mutually reinforcing to create and capture (i.e., monetize) value (Hui, 2014).

Entrepreneurs will be needed who can create new industries and new wealth from technological innovations (Hamidi & Jahanshahifard, 2018). The barriers to entry for smaller and more innovative competitors will be lower because of the developments in technologies. Improvements in market and customer intelligence in every sector, gained by unlocking the insights available from Big Data, will support entrepreneurial activity (Chan, 2015; Lokshina et al., 2017a; Lokshina et al., 2017b; Lokshina et al., 2018).

New business start-ups will be attracted by the possibility of strategizing more precisely while reducing the level of uncertainty for their decision-making (Chan, 2015). Smaller businesses will be able to compete more effectively with larger, more-established firms because of the enhanced information and their ability to react more quickly and efficiently to changes in the market. To prepare for these changes, managers should begin to collect more data, recruit and retain the best digital talent, retrain existing staff and plan how to restructure the organization (Bucherer & Uckelmann, 2011; IBM, 2008; Lokshina et al., 2017a; Lokshina et al., 2017b; Lokshina et al., 2018).

Competitive advantage can be gained by scanning the environment for emerging opportunities created by the IoT. Big Data is significant in its ability to provide information and knowledge for decision-making. The historic and real-time data generated through supply chains, production processes and customer behavior provide a host of opportunities to generate wealth when properly analyzed to reveal valuable insights. The main categories of organizations that can benefit from big data analytics include manufacturing, retail, central government, healthcare, telecommunications, and banking (Chan, 2015; Dijkman et al., 2015; Lokshina et al., 2017a; Lokshina et al., 2017b; Lokshina et al., 2018).

Chan (2015) discussed how organizations have already begun to integrate big data and the IoT applications into their business models. For example, Smart TVs installed at shopping malls provide an opportunity for companies to evaluate the effectiveness and return on investment of digital signage and point-of-purchase displays through Cloud Audience Analytics. A video "presence detection" solution, it provides shopper analytics with profiles by gender and age, for example. In real-time, appropriate advertising will be displayed and insightful information will be collected and reported to improve advertising effectiveness.

Collaborators include the provider of the analytic software and gateway; the provider of the mobile network and Cloud facility; and the advertiser that provides the advertising message. Each of the collaborators benefits from this arrangement. The advertiser receives data concerning the viewer profile, the return on investment and the effectiveness of the advertisement. The provider of the digital signage with the camera and transmission modem receives revenue from its role as the cloud service platform. Finally, the provider of the data analytics is enriched by the imposition of service charges.

Other companies recognize their role as providers of after-sale services, remotely monitoring and diagnosing issues in the system. Companies can apply technologies such as RFID to their specific industry and collaborate with other parties in their ecosystem (Chan, 2015; Lokshina et al., 2018; Lokshina & Thomas, 2013).

Information platforms offering comprehensive public transportation information can be developed using open data released by the government together with data collected from the Internet to offer comprehensive and up-to-date information for users. A large customer base can be built for use with advertising and other add-on features (Chan, 2015; Lokshina et al., 2018). Using a digital freemium business model, the application can be offered at no cost for users with its main source of revenue from mobile advertisements. Collaborators include complementary service providers, such as food delivery and taxis, which rely on location-based technology and generate revenue through service charge (Chan, 2015; Lokshina et al., 2018).

The use of the components of value proposition, customer relationships, and key partnerships identified by Dijkman et al. (2015) will increase in importance as companies seek to develop their business models in response to the evolution of the IoT (Dijkman et al., 2015; Lokshina et al., 2017a; Lokshina et al., 2017b; Lokshina et al., 2018).

Evaluation of Business Models Operated by European SMEs in IoT- and Big Data-Driven Data Analysis Services

In the following subsection, the authors evaluated some experiences of European small and medium enterprises (SMEs) with data analysis services related to the IoT and Big Data. A critical approach (Scuotto et al., 2017) was followed, and anonymous data and information were presented so as not to interfere with the interests of the companies involved (Lokshina et al., 2017a; Lokshina et al., 2017b; Lokshina et al., 2018).

The following scenarios are used to illustrate the issues involved in each case:

- Collection of information and privacy while safeguarding privacy of customers and third parties;
- IoT data collection and data analysis; and
- Data collection suitable for Big Data purposes.

Collection of information while safeguarding privacy of customers and third parties is a major issue especially in small organizations. It is difficult there to divide responsibilities and to avoid conflicts of interest. Questions arise such as who controls whom, who has access to which customer's information, and whether customers and third parties support or endanger privacy (Lokshina et al., 2017a; Lokshina et al., 2017b).

Case A: A small law office in Belgium. Contacts with customers and third parties go through a single e-mail address. For important written information, privacy for client and third parties is an option, not a guarantee.

The authors conclude that this organization does not have to change its business model. However, it may have to change its privacy related practices, as these look incomplete, and maybe not sufficient to meet the requirements of the new European General Data Protection Regulation (GDPR) - Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data and repealing directive 95/46/EC (Official Journal of the European Union, 2016; European Commission, 2018; Lokshina et al., 2018).

Case B: A medium size doctors' group in Switzerland. In line with practices commonly supported by Swiss public and private health insurances, health support is on a "Managed Health" basis. Contacts with customers (e.g. patients) and users are through a web-based, individualized communication system, with controlled, role-based access implemented for the group. However, customers and users tend to bypass what they perceive is a difficult system and use e-mails to others in the group, thereby undermining privacy protection. Furthermore, given the absence of effective standardization of eHealth interchange systems, the guarantee of privacy is compromised in communication with and among clinics and hospitals.

The authors conclude that this organization has adopted a business model that in principle includes IoT elements in the form of the "Managed Health" (Lokshina et al., 2018). Its procedures ensure a sufficient privacy protection, however, users (including patients) and medical and support staff will have to be educated to strictly follow the procedures and avoid as much as possible informal communications.

Case C: A small real estate management agency in France. Contacts with customers and users are through a web-based, individualized communication system, with controlled, role-based access implemented for the group. However, in such an organization with a small number of employees, roles will inevitably overlap. This increases the risk of compromised access to financial data and information of the customers and users, which must be protected to respect their privacy interests. Collecting data and data analysis while safeguarding privacy is a major challenge even for larger organizations.

The authors conclude that this organization may be considered too small to effectively implement strict privacy procedures (Lokshina et al., 2018). The IoT is not yet far enough implemented to affect the operations and business model. However, it may be expected that this will happen in the next five to ten years, when IoT information on water and energy consumption, for example, will become accessible to the agency.

Case D: An elevator maintenance company in Italy. Modern elevators have sensors to gather data, but in many installations, users do not permit to support remote access to the observations collected. Therefore, data analysis is a low priority for this company. This also does not support access to a preventative maintenance market. Data analysis is done on an ad hoc basis without the support of specialized tools.

The authors conclude that this organization is not yet affected by the IoT tools it has at its disposal (Lokshina et al., 2018). However, this is expected to change in the next five years, affecting operations such as scheduling, but most importantly, a steady shift to more preventative maintenance. The latter will affect the business model mainly in its application and execution.

Case E: A utility meter data collection company in Italy. Energy consumption data is collected for town heating systems. Most installations do not allow remote, or even non-contact, meter reading because of perceived cost and privacy protection reasons. (In comparison, the Italian electricity distribution network is more advanced in supporting both remote and contactless access). Consequently, data analysis is a low priority for this company, as current practices do not support access to an analytics services market.

The authors conclude that this organization will be strongly affected by both IoT developments and privacy issues (Lokshina et al., 2018). Regarding the former, remotely readable meters will strongly simplify collecting data. However, there are privacy related issues when the data of individual users must be shared, for example, in a condominium environment for the purpose of allocating costs and contributions. The business model of the organization does not have to change to accommodate these changes. However, if the organization starts offering additional services, such as analytics and/or curative or preventative maintenance, then that would require amendments to its business model.

Case F: A utility meter data collection company in Belgium. All utility meter readings are collected for different distributor clients (i.e. water, electricity, and gas). Currently various methods of data collection exist including customer- and user-supplied information and ad hoc meter reading by agents. A transition is under way to implement remote and non-contact reading of meter information, but this has been made a rather long term, 15-year operation by the authorities. Data analysis is applied to verify all meter readings, identify a fair percentage of errors in documented information in reports as well as detect malfunctioning meters. The company also provides an analysis of consumption patterns to the distributors who relay the information to their customers and users.

The authors conclude that this organization does not have to change its business model but can increasingly embrace new technologies that will allow it to do finer analytics and significantly decrease response time on artifacts such as leaks, technical failures or other problems (Lokshina et al., 2018).

Currently, few small companies have the motivation and resources to apply Big Data techniques. In many cases, they lack the competence to even evaluate the possible use of Big Data. The scenarios discussed above illustrate that a favorable environment for Big Data applications does not exist as of now.

The exception is Case F. Initially the objective of the company was to verify customer- and user-supplied meter readings to save costs for the company and its distributor clients. The use of Big Data techniques provided an analysis of consumption trends integrating historic consumption patterns with some other data such as temperature and holidays. These results could be of interest not only to the distributor clients but also to their customers and users. The company ensures privacy protection for customers and users with a web-based personalized system. Customers have so far accepted the risk that Big Data techniques may make privacy-sensitive information more visible to the staff of both the utility meter data collection company and its client distributors (Lokshina et al., 2018).

Evaluation of Potential Business Opportunities in IoT- and Big Data-Driven Data Analysis Services for Third Parties

Whereas business models for the IoT equipment and infrastructure have not been discussed in this chapter, it must be emphasized that the provision of services based on IoT depends on the existence and access to the IoT infrastructure. Therefore, the speed with which the service market can develop may depend on the roll-out of suitable IoT infrastructure (Lokshina et al., 2017a; Lokshina et al., 2018; Scuotto et al., 2017).

It may be expected that organizations will invest in data collection with immediate commercial interest and will be hesitant to invest in data collection that does not immediately add to productivity or quality. For Big Data applications, organizations may therefore have difficulty getting access to the necessary data sets. Suitable data sets may exist within the primary interest of other organizations, therefore also subject to considerable privacy and confidentiality considerations and possibly financial obligations and restrictions (Lokshina et al., 2018).

One solution for this issue could be industry-wide access agreements across sectors for this purpose. Another solution, like one used by media services, could be the provision of access to data sets or packages of data sets via a broker or packager, possibly adding another level of anonymity. However, that, by itself, may also compromise the usefulness for Big Data purposes as well as for regulated clinical medical tests (Lokshina et al., 2018).

The expansion of the IoT and Big Data will have significant implications for small businesses (Foreman, 2014; Shein, 2015). Currently, many enterprises are not able to take advantage of the IoT and Big Data. At present, only the largest of enterprises have access to the level of required resources. This means, then, that the large companies often dominated sectors of industries as they relied on their extensive resources, including financial and informational, to perform analysis and to support the required infrastructure (Lokshina et al., 2018). Larger operations, such as Coca-Cola, General Electric and Domino's Pizza, have already begun to use the resources of Big Data and the IoT to provide value to their organizations (Hayles, 2015). Boston Consulting Group (BCG) projects that, in the aggregate, companies will spend an incremental €250 billion (i.e., $267 billion) on IoT in 2020, which is over and above their normal technology spending. Three industries will account for approximately 50% of IoT spending: discrete manufacturing, transportation and logistics, and utilities (Hunke, Yusuf, Schmeig, Bhatia, & Kalra, 2017; Lokshina et al., 2018).

In the past, the requirement of heavy capital investment has created significant barriers to entry and prevented a level playing field for small businesses. (Foreman, 2014). The cost of IoT systems is expected to drop and the use of cloud services to store and analyze data will become more prevalent. These factors should reduce operating expenses and make the use of the IoT and Big Data more affordable for small businesses (Lokshina et al., 2018). Cloud service providers (CSPs), such as Amazon Web Services (AWS) and Microsoft Azure, together with analytics and infrastructure software vendors now have significant influence over the IoT solutions being purchased by organizations. Simpler implementations are now available, making it easier for even small businesses to try out new use cases and become operational more quickly (Bosche, Crawford, Jackson, Schallehn, & Schorling, 2018). However, a survey conducted by the consulting firm Bain & Company indicated that customers believe the most significant barriers to IoT adoption have not been adequately lowered by vendors. These barriers include security, ease of integration with existing information technology (IT) and operational technology (OT) systems, and uncertain remains on investment. Accordingly, customers in 2018 were planning less extensive implementations by 2020 than they were forecasting in 2016 (Bosche et al., 2018).

As digitalization becomes more commonplace, barriers to entry will be reduced (Lokshina et al., 2018). Because of these technologies, products and services will be commoditized, with small businesses competing with large companies for individual modules. The "plug and play" nature of digital assets will cause the value chains to disaggregate. Existing value chains will change resulting in opportunities for new business models (Kiel, Arnold, Collisi & Voight, 2016). This will permit focused, fast-moving competitors, many of whom can scale up more rapidly and at a lower cost, to enter the market (Hirt & Willmott, 2014).

Entrepreneurs, using mined data to determine preferences of customers, will "cherry pick" subcategories of products and undercut prices on small volumes (Lokshina *et al.*, 2018). This will force larger companies to do the same. Porter and Heppelmann (2014) predict that as the use of the IoT becomes more prevalent, the bargaining power of buyers and sellers will increase, and the level of competition will significantly increase.

It is expected the analytic tools required to process large volumes of data will become more accessible to small businesses, which will benefit by adopting Big Data strategy. However, new market entrants may need to rely on experts to provide technical solutions. The broad horizontal services offered by the large CSPs will provide an opportunity for systems integrators, enterprise app developers, industry IoT specialists, device makers and telecommunication companies to provide industry-specific solutions (Bosche et al, 2018). There is a danger implicit in this arrangement since managers of small businesses may not have the expertise to supervise the experts (Lokshina et al., 2017b). Additionally, by concentrating the responsibility primarily with outside consultants, there is an increased risk of conflicts of interest and potential ethical violations (Lokshina & Lanting, 2018a).

Gartner analysts predict that the IoT will have a significant impact on the economy and will transform many enterprises into digital businesses. New business models will be facilitated, efficiency will be improved, and employee and customer engagement will be increased (Hung, 2017). A 2017 Forbes Insights survey by Forbes of over 500 executives found that almost two-thirds (64%) of companies believe the IoT is important to their current business, and over 90% believe it will be important to the future of their business. The potential of the IoT is not limited to large businesses, however.

In a survey of small businesses conducted by AVG in 2014, 57% of the respondents expect the IoT to have a significant impact on their bottom line (Foreman, 2014). Michael Feldman, an IoT product engineering consultant, has observed that the opportunities for the use of IoT will be limited only by the imagination of entrepreneurs, and the key elements for successful ventures will be defined as follows: identify why a particular device should be connected, what data will be obtained, and what kinds of decisions can be made with that data (Schein, 2015.)

Small businesses will have the opportunities to capitalize on the expansion of the IoT in several ways (Lokshina et al., 2018):

- Improve the efficiency of internal operations;
- Create innovative products and services for consumers and other businesses; and

- Provide technical and consulting services to other businesses.

The IoT can help small businesses improve the efficiency of their internal operations. It can provide control, optimization, monitoring and autonomy in organizations (Lokshina et al., 2018). In addition, small businesses can use security alarms and other sensor-based systems, such as IoT thermostats and air conditioners to control air conditioning and heating costs. With better access to data and the resultant better decisions, plants could be run more efficiently and more safely (Shein, 2015; Lokshina & Lanting, 2018a).

A 2017 Gartner IoT survey found that the most significant internal benefits to enterprises of all sizes included increased worker productivity, remote monitoring and control of operations, and improved businesses processes. Businesses are incorporating IoT into their operations including using IoT-enabled carts to follow employees in warehouses, pulling up part information from wearable technologies, assisting with asset tracking, increasing supply chain visibility and improving processes (Liu, 2017).

Employees have been affected by the IoT and Big Data (Barbato, 2015; Durkin & Lokshina, 2015; Lokshina et al., 2018). Sociometrical badges provided to employees can be used to measure behavioral response data and are mapped to important metrics including sales, revenue and retention (Lindsay, 2015). While large clients such as Bank of America and Deloitte are using the Humanyze sensors, one can only anticipate that the concept with eventually trickle down to small businesses eager to capitalize on the return on investment. Deloitte has identified several possible employee-related IoT applications.

Sociometric data such as tone of voice and rate of gesture can be used to measure employee engagement and factors correlated to team cohesion. Aggregated performance data can provide a sense of team performance without identifying individual members. Data filtered by task type can help individuals to enhance individual time management skills and to schedule meetings when individuals in a group are most likely to be engaged. (Bersin, Mariani, & Monahan, 2016). The concept of "digital Taylorism," with its focus on quotas and efficiency, has the possibility to affect knowledge workers as well ("A Modern Version," 2015; Durkin & Lokshina, 2015; Lokshina et al., 2018).

These innovations in large companies, once refined, will become standard metrics in organizations of all sizes. By identifying existing problems or ideas, entrepreneurs can develop solutions using IoT and Big Data to create innovative products and services (Lokshina et al., 2018).

Finally, small businesses can develop business opportunities by providing technical and consulting services to other businesses. The value of IoT goes beyond the data. Services are still needed to protect the data, perform analysis, and present the findings. Small businesses can be an integral part of these activities (Durkin & Lokshina, 2015; Lokshina et al., 2017a; Lokshina et al., 2018).

Evaluation of Possible Effects of the Introduction of 5G

The introduction of the 5th generation (5G) of wireless communication systems will be, over time, a major catalysator for IoT and Big Data services (Lokshina, Zhong & Lanting, 2020). Specifically, because of the key characteristics, or key performance indicators (KPIs) advocated for 5G solutions that can be summarized as follows:

- 5G will be able to increase the spectral efficiency (expected to increase by a factor of 5 to 15 compared to 4G), which results in the properties listed below;
- 5G will be able to satisfy the demands of massive connectivity for IoT (the connectivity density target is ten times higher than that of 4G);
- 5G will eventually be able to achieve lower cost (up to an estimated 100 times the cost efficiency of 4G);
- 5G will be able to satisfy the requirements of low latency; and
- 5G will be able to support diverse compelling services.

Due to its versatility and ubiquitous presence, 5G will be de-facto the network of choice for most IoT applications, as a unifying wireless communications network with harmonized access. Given that, contrary to what is often assumed, IoT requirements may include, in addition to low data rate communications, also medium and high data rate communications, 5G will provide the following advantages:

- Ubiquitous availability, large coverage locally, regionally, domestically and internationally;
- Ability to support efficiently low, medium and high-data rate communications;
- Harmonized access to the different services; and
- Access to edge computing.

However, these advantages will become available over time, and not all services and advantages will be available everywhere: highest data-rate and low latency services may not be available, at least for some time, in less densely populated and/or visited areas: the deployment of both IoT and supporting 5G infrastructure will need time for deployment. Furthermore, 5G will not obsolete but will coexist with other solutions, such as Wi-Fi, low-data rate WAN wireless systems and satellite links (Lokshina, Zhong & Lanting, 2020).

A somewhat surprising link that seems to be made often in the press is linking artificial intelligence (AI) and autonomous vehicles with 5G. To be clear, one does not need 5G for neither AI nor autonomous vehicles. A different set of questions then is whether 5G can be helpful for certain applications of AI or autonomous vehicles:

- 5G may help transferring larger amounts of data with higher speed and with lower latency;
- 5G may provide access to edge computing facilities.

However, and this is particularly important for “autonomous” vehicles:

- Reliance on 5G services may introduce a dependency on the availability, resilience and quality of the 5G based services being used and relied on.

Nevertheless, 5G is already and rapidly gaining importance for IoT and, in particular, for SMEs intending to apply IoT, because:

- Its deployment and availability are certainties: the question is not “if” but “when”;
- It provides a unified, harmonized and standardized access to a large variety of services; which in turn supports the following:
- It simplifies application to IoT device communications, interfaces and APIs;
- It avoids the need for multi-network support designs as a base requirement; instead, supporting several networks would be for allowing cost and performance optimization in each application environment, rather than for making devices ubiquitously usable.

CONCLUSION

This section suggests future research directions and offers concluding remarks. To date, much attention and effort have gone in the development of business models, for the provision of services in a major, global data-driven ecosystem in the context of IoT and Big Data. These business models assumed the existence and development of the necessary IoT measurement and control instruments, communications infrastructure, and easy access to the data collected and information generated by any party. However, not all business models may possibly support opportunities that generate revenue or value or are suitable for different types of customers. The authors recommend that other business models should also be considered.

This chapter makes three important contributions to the literature. First, the chapter evaluated knowledge-based management practices, business models, new ventures and potential business opportunities for third-party data analysis services. It complemented other research on the positive effect of knowledge management on companies' innovative performance.

Second, the chapter discussed access to information generated by third parties in a new context of analysis, i.e. as a prerequisite to data analysis services and in relation to Big Data techniques and new business opportunities. It complemented prior research done by the authors on access to data from third parties by Big Data analyzers.

Third, the chapter considered strategic implications and new business opportunities for small businesses that use IoT in data-driven ecosystems. It complemented other research concerning the positive effects of ICT tools and competencies on business performance.

Finally, this chapter also has some social implications since governments are interested in using the latest technologies to promote the best social climate for their citizens. In fact, the use of IoT in data-driven ecosystems provided significant potential for crowdsourcing of markets and networks, as well as for smart networking. The chapter assumed that an obvious consequence of using the latest technologies will be a broader scope of deliberate democracy.

However, the legal framework of the latest technologies is still considered rather vague or absent to a certain extent. Such issues as standardization, service design architecture and models, as well as data privacy and security create management and governance problems. These issues have not been solved completely by the current service architectures. The latest technologies can also become subject to power politics with the attendant risks of cyberwar, cyberterrorism and cybercriminality.

Furthermore, the current research has several limitations. First, the study of a single context of analysis could reduce and limit the generalizability of results. There is, therefore, a need for additional research to determine whether knowledge management and ICT capabilities play the same role in other high-tech contexts. Second, the research is limited by the choice of companies involved. Further research could document additional quantitative and qualitative examples where SMEs have developed strategic opportunities by providing technical and consulting services to other businesses.

In conclusion, then, the offering and size of the market for third-party data analysis may be expected to develop as follows. The rate of development of the data services market will be limited by the speed of the roll-out of the relevant IoT infrastructure.

For Big Data applications, dependency includes access to additional data sets. These, in turn, will be dependent upon roll-out, privacy and confidentiality concerns as well as additional conditions and constraints.

Small companies will call on affordable and less sophisticated data analysis services by third parties. Large companies will call from time to time on the services of highly specialized data analysts, who maybe better referred to as difficult problem solvers.

ACKNOWLEDGMENT

The authors wish to extend their gratitude to the anonymous reviewers for their time, assistance, and patience.

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KEY TERMS AND DEFINITIONS

Big Data: Extremely large volume of data - both structured and unstructured - that inundates a business on a day-to-day basis and may be analyzed computationally to reveal patterns, trends, and associations, especially relating to human behavior and interactions.

Big Data Analytics: The process of examining big data to uncover hidden patterns, unknown correlations, market trends, customer preferences and other useful information that can help organizations make more-informed business decisions.

Business Model: A design for the successful operation of a business, identifying revenue sources, customer base, products, and details of financing.

Business Venture: A small business. Many ventures will be invested in by one or more individuals or groups with the expectation of the business bringing in a financial gain for all backers. Most business ventures are created based on demand of the market or a lack of supply in the market.

Data Analysis: A process of inspecting, cleansing, transforming, and modeling data with the goal of discovering useful information, informing conclusions, and supporting decision-making.

Digital Society: A modern, progressive society that is formed as a result of the adoption and integration of Information and Communication Technologies (ICT) at home, work, education and recreation, and supported by advanced telecommunications and wireless connectivity systems and solutions.

Ethics: The branch of knowledge that deals with moral principles.

Internet of Things (IoT): A system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

Knowledge Management: The process of creating, sharing, using and managing the knowledge and information of an organization. It refers to a multidisciplinary approach to achieving organizational objectives by making the best use of knowledge.

Small and Medium-sized Enterprises (SMEs): Non-subsidiary, independent firms which employ fewer than a given number of employees. This number varies across countries. The most frequent upper limit designating an SME is 250 employees, as in the European Union.

Smart World: A concept of a digital world that evolves from the definition of ubiquitous computing and promotes the ideas of a physical world that is richly and invisibly interwoven with sensors, actuators, displays, and computational elements, embedded seamlessly in the everyday objects of our lives, and connected through a continuous network.

Chapter 8
Time-Bounded Decision Making:
What We Need to Know About Knowledge

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ABSTRACT

How to manage uncertain and unpredictable situations has been a major challenge facing managers and academics for decades. The development of practice and theory in knowledge management has been one important response. This chapter, however, argues that knowledge and knowledge management may not be sufficient when dealing with emergent and unforeseen situations as knowledge tends to be past-oriented in terms of its formative components, while emergent situations are future-oriented, which may or may not be rooted in the past. Therefore, authors explore this past-present-future conundrum by explaining how mere reliance on the past may restrict organizations' ability to deal with emergent situations in the future. Finally, the role of innovation and wisdom will be introduced as a bridge connecting current past-oriented knowledge to unknown and unpredictable future-oriented events.

DOI: 10.4018/978-1-7998-2355-1.ch008

INTRODUCTION

Today, businesses operate in a considerably more volatile environment than businesses in the past. Environmental stability in the past created a world of relatively simple systems where Newtonian perspectives could be applied to organizational decision making. Events seemed predictable, organizations had mechanical characteristics, expectations of regularity were achievable, causal relationships and limitations were well-defined, and 'tried and true' principles, rules and policies managed behaviors (Stumf, 1995). Nowadays, however, volatility and instability, products of time-compressed and information-rich environments, cause high levels of uncertainty and are regarded as distinctive characteristics of the current world (Buckley & Carter, 2004). The future is no longer seen as a reliably certain continuance of the past and present (Intezari & Pauleen, 2014). Tremendous and ever-increasing rates of technology advancement as well as increasing uncertainty spurred on by an interconnected global environment make the future unpredictable. Problems are multi-causal and trends are rarely linear, simple decisions may no longer be appropriate and any attempt to solve a problem may lead to uncertain and unplanned results. To cope with continual changes in global markets, organizations must be willing and able to continually change (Cash, 1997). Traditional organizational perspectives on the environment may no longer be appropriate or sufficient.

The development of practice and theory in knowledge management has been one important response. Knowledge is one of the most valuable and vital assets an organization can have (Drucker, 1993). Success is not necessarily achieved, however, by the organizations that know the most, but by the ones that can best use what they know (Bierly et al., 2000). Moreover, the nature of knowledge, including its sources and uses, must be carefully considered. A clear understanding of what knowledge is and of its strengths and weaknesses is essential if organizations are to successfully cope with rapid and emergent changes.

The challenge of managing knowledge in a turbulent business world must address these questions: to what extent can organizations trust their information, experience and their previous knowledge to prepare for future circumstances and what else can assist them when facing future situations never seen, experienced or possibly imagined?

This chapter is organized into four main sections. In the first section, knowledge, the source of knowledge and the use of knowledge are discussed. The second section discusses the role of knowledge and managing knowledge in emergent business environments is examined. This is followed by an introduction to wisdom theory and the proposition that a blended approach of analysis/rationality and insight/non-rationality is a possible way to overcome a lack of appropriate knowledge when confronting uncertain and unpredictable situations. Finally, it will be proposed that developing innovative and more effective responses to deal with complexity requires an integration of knowledge and wisdom in organizational learning systems.

SOURCES OF KNOWLEDGE

Taking a continental philosophical perspective on knowledge and knowledge management, Hassell (2007) argues that knowledge is embodied. He articulates knowledge by differentiating between 'computerized knowledge' and 'embodied knowledge', and notes that knowledge resides in a physical human being and, therefore, there is no knowledge outside of experience. Knowledge is associated with a social group as knowledge develops and manifests through human action in a societal context. In this sense, knowledge engages emotions, which makes any attempt to capture knowledge doomed to failure (Hassell, 2007). Computerized knowledge is simply un-/semi-structured and structured data. Knowledge management systems cannot computerize embodied knowledge (or as stressed by Hassell, "the real knowledge").

We extend Hassell's understanding by arguing that not only do knowledge management systems fall short in capturing embodied knowledge, in their contemporary forms such systems may not be very useful in supporting decision making in unpredictable and unforeseen circumstances. From the current mainstream knowledge management perspective, knowledge can be developed from data and information and likewise, knowledge can be converted back into information and located in an information system. Hassell would call this type of knowledge, 'organized stuff' (2007, p. 189). Central to our argument is that data and information are past-oriented, which makes knowledge built on data and information past-oriented in nature as well.

It is difficult to find a universally agreed upon definition of 'knowledge', as there are many perspectives regarding knowledge (Krogh et al., 2000). Philosophically, knowledge is defined as a justified true belief (Nonaka, 1994; Weatherson, 2003). That is to say, our belief is knowledge if we have a true justification for it. Although this understanding of 'knowledge' has endured over centuries, there are numerous debates in philosophy about whether or not such a definition of knowledge accurately describes the concept of knowledge. Gettier, for example, logically demonstrates that a justified true belief may not be knowledge (see Gettier, 1963, p. 122). Rather than engaging in an extensive philosophical debate, here we examine knowledge from a managerial perspective.

In the information management literature, a widely recognized approach to understanding knowledge is the knowledge pyramid model (also known as 'information hierarchy' or 'knowledge hierarchy') proposed by Ackoff (1989). In this approach, knowledge is defined by differentiating between knowledge, information and data (Davenport & Prusak, 1998; Hicks et al., 2006). That is to say, information becomes knowledge when it is combined with an individual's experience and interpretation in a particular context (Harris, 2005; Nonaka, 1994). Though simplistic, the hierarchy does illustrate the importance of information in the development of knowledge. Nonetheless, the model has come in for criticism. For example, Jennex and Bartczak (2013) argue the model is an artifact of KM processes and not representative of reality. Wognin et al. (2012) criticize the pyramid approach for failing to consider and provide an explanation of how each level is transformed into a higher level: i.e. data into information, and information into knowledge. The argument here is that knowledge is needed at each of the levels, e.g., knowledge is needed to know what data needs to be collected and how to collect it, and knowledge is again needed to transform information into knowledge (Davenport & Prusak, 1998).

Frické (2009) raised a methodological critique challenging the functionality of the pyramid in the real world. This critique is closely aligned with the core premise of this chapter. Frické (2009) argues that the hierarchical model draws on a 'pre-emptive acquisition' (p. 135) assumption, which encourages a meaningless and mindless collection of data in the hope that one day the data is processed to form information, and that this information will answer questions. He gives the example of 'data warehouses', which collect as much data as possible, awaiting data mining for information.

The recent emergence of the concept of 'Big Data' testifies to how the faith in informing decisions with ever-growing amounts of data continues to grow. While the technology around big data can now bring data collection into the near present – the 'velocity' of the Three V's of Big Data (volume, variety and velocity) (Davenport et al., 2013; Delen & Demirkan, 2013) – the fourth V (veracity) i.e. the accuracy of the data is more problematic (Jagadish et al., 2014; Sathi, 2012). Moreover, following Wognin et al. (2012) the analysis of big data (analytics) is still based on human-generated algorithms, which are based on human knowledge. We will return to this point later in the chapter.

Schön (1987) defines knowledge as "accumulated external and explicit information belonging to the community, being leveraged by tacit intrinsic insights which originate within individuals who then may act alone or cooperatively in order to control or integrate with their environment" (as cited in Ahmad et al., 2009, p. 3). This pragmatic definition points out key qualities of knowledge: explicit and tacit individual and social participation, and its use in light of the wider environment. This definition shows genuine promise as a starting point in understanding the role of knowledge in managing in unstable business environments. But where does knowledge come from and how can it be used?

Knowledge resides in the human mind (or as Hassell states, in the human body), which means finding the real and exact source of knowledge is an 'Arthurian' quest. This is because knowledge is inextricably linked with culture, commitment and common values (Hassell, 2007). While knowledge does not come from simple database analysis or information transmission mechanisms, there may nevertheless be value in looking at the somewhat linear data-information-knowledge (DIK) model that has knowledge resting on a foundation of data and information. The definition provided in the previous section explains knowledge as information leveraged by individual insight. To put it simply, when information is combined with people's experience and interpretations, and when individuals tailor and mobilize information, it becomes a knowledge source (Kreiner, 2002; Liew, 2013). For this reason, prior knowledge is considered one of the main sources of knowledge (Carneiro, 2000; Nielsen, 2006). Other factors relating to knowledge creation are human perception, discovery and learning, which are regarded as sources of knowledge (Harris, 2005). This clearly supports the contention that individuals play a crucial role in the process of transforming information into knowledge. We can comfortably agree that the sources of knowledge, as Ray (2008) states, are people and information.

Another view as to the sources of knowledge pertains to the relationship between knowledge and experience. Knowledge, as Roberts and Armitage (2008) express, is one's understanding obtained through experience and observation. One of the philosophically influential perspectives on this issue belongs to Kant, who differentiated between a priori knowledge – independent of experience – and a posteriori knowledge – derived from experience (Trusted, 1997). Knowledge can be innate and acquired through non-inductive means. One can have "a priori knowledge of what exists as a result of knowing the subject and the objects of knowledge - being in some sense and to some degree pre-tuned to each other" (Kurtus, 2002, par. 13-14). A posteriori knowledge is past-oriented as it is rooted in one's experience, through observation and experiments.

When it comes to the turbulent business world replete with numerous emergent phenomena, the source of knowledge becomes a fundamental concern. Unless there is a yet undiscovered mathematical equation for predicting the future, positivism would seem to be of limited value. Even if we accept that the sources of knowledge are to at least some degree based on *information*, *experience*, and *previous knowledge*, we are still faced with the question of just how useful previous knowledge is when confronted with unpredictable and emergent future events and situations. Quite aside from the effects the sources of knowledge have on managing knowledge, the reasons that a body of knowledge is developed in an organization or a particular business field can have immense impact on knowledge management, and so it is important to understand what knowledge implementation is and what it is used for. Knowledge creation in an organization must be aligned with knowledge implementation, which eventually must enhance an organization's ability to effectively handle market and industry requirements and changes.

KNOWLEDGE IMPLEMENTATION

While knowledge for the sake of knowledge may be virtuous (Trusted, 1997), the worth of knowledge is in its implementation and the subsequent value accrued. As Alavi and Leidner (1999) note, knowledge as a justified personal belief enhances one's "capacity to take effective action" (p. 5). Similarly, Martensson (2000) states that transforming information into knowledge would be in vain if it did not lead to an "informed decision or action" (p. 208). An effective action may be either one's success in finding a desired job or an organization's success in gaining market share for a new product.

From the managerial perspective, applying knowledge is a major source of competitiveness (Grant, 1996), and the ultimate goal of knowledge management is to help people to put knowledge into action in order to improve organizational performance and maximize profit (Huseby & Chou, 2003). This shows that knowledge implementation is considered a critical activity in organizational knowledge management strategies. But what exactly does this activity refer to?

In management, knowledge implementation has been explained in different ways depending on organizational goals, research purposes, and theorists' perspectives. The main conclusion of most research, nonetheless, is the same – knowledge is implemented to increase organizational effectiveness, efficiency and, in turn, to improve competitiveness (Schultze & Leidner, 2002). While some scholars (Newman & Conrad, 2000; Srinivasan, 2004) generally define the implementation of knowledge as the connection between knowledge and business to gain competitive advantage, others (Shariq, 1997; Nielsen, 2006) explain knowledge implementation operationally as an embedding process through which knowledge is incorporated into products and services. At any rate, almost all theorists have the same approach to the philosophy of knowledge at the organizational level and for the purposes of this chapter can be summed up thus: *knowledge is used for accurate decision making and, in turn, for promoting organization performance* (Martensson, 2000; Van Beveren, 2002). However, how would knowledge help organizations improve their performances in a volatile environment where events are likely to be unforeseen and unpredictable?

This concept will be discussed further in the final paragraphs. But first, it is important to understand the emergent future and the unpredictability of the business world.

Unpredictability and the Knowledge Sources of Decision Making

Complexity and unpredictability are the main issues managers face in an unstable business environment. Good judgment, effective decision-making, and innovative and proper action are critical capabilities for all organizations at all times, but especially when faced with unanticipated circumstances. By unanticipated circumstances, we mean the manifestation of new phenomena or events that are impossible to predict. These are the circumstances that an organization or manager has never experienced before and for which their knowledge may be irrelevant or inadequate.

What must be considered as a matter of great concern to organizational leaders and those who are involved in strategic decision-making is that concentrating on managing knowledge only may not necessarily lead to accurate judgment, effective decisions and responsive actions (Figure 1).

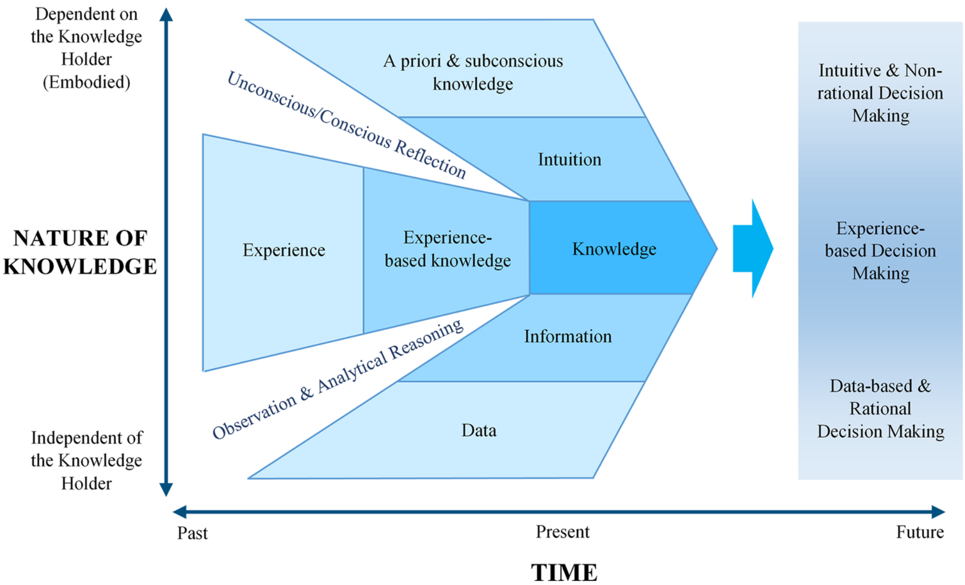
Figure 1 illustrates the nature of the sources of knowledge and how the sources may be time-bounded. The vertical axis represents the nature of knowledge along a continuum of being either independent of or dependent on the person. The horizontal axis depicts the time-bounded nature of the sources of knowledge along a past-present-future conundrum (Intezari & Pauleen, 2019).

One's knowledge may be based in part on a conscious analysis of data and information. In this sense, as is the prevailing approach in management information systems, knowledge is seen as a quality that is independent of the person, and therefore, can be computerized and stored in information systems.

Knowledge can also be developed based on experience and or conscious analyses of previous observations or experiences. Experience-based knowledge is 'know-how'. Know-how is the knowledge of applying previous experiences, for example, by reflecting on previous decision-making experiences. By analyzing and reflecting on previous experiences, the decision-maker tries to understand how those experiences are related and applied to the current decision situation. Reflection plays a critical role in acquiring experience-based or intuitive knowledge (Intezari & Pauleen, 2013).

Another source of knowledge in decision-making is *a priori knowledge,* and intuition, which is highly dependent on the knowledge holder. Intuition, as a way of knowing, refers to the capacity to know something instantaneously and without conscious effort (Nyatanga & Vocht, 2008; Volz & Cramon, 2006). Intuitive knowledge is rooted in one's unconscious analysis of and reflection on previous experiences and observations (Intezari & Pauleen, 2019). Intuition is linked to emotion and feeling (Evans, 2012), and draws on subconscious data and on an internal process of feeling or sensing (Effken, 2001). Intuition allows a decision maker to effectively deal with even complex decision situations without conscious reasoning or objective analysis (Eubanks, Murphy, & Mumford, 2010).

Figure 1. Decision types and knowledge sources (adapted from Intezari & Pauleen, 2019, p. 131)



Unpredictability, an Inevitable Decision Situation

While events may be predictable in mathematics, physics or other mathematics-based disciplines, the situation in social science is different. As we move from the hard sciences to the social sciences, knowledge moves from being objective to subjective (Brier, 2008). In social sciences, people are the subject of study and this moves us into the realm of complexity (Schneider et al., 2016; Griffin & Stacey, 2005; Stacey, 1996), as individuals' unpredictability and intellect make it impossible to model human behavior (Snowden & Boone, 2007) and establish a universal rule predicting future behavior. In this sense, complexity refers to the number of elements involved in a system and/or the environment of a system, as well as to the relations between these elements (Schneider et al., 2016). A definition provided by the Santa Fe Group clearly explains the complexity of the world we (as individuals or organizations) face (Battram, 1998):

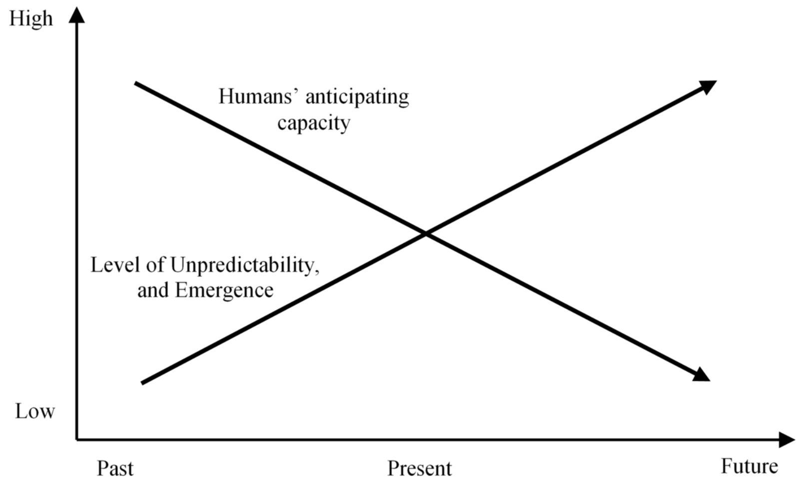
"Complexity refers to the condition of the universe which is integrated and yet too rich and varied for us to understand in simple common mechanistic or linear ways. We can understand many parts of the universe in these ways but the larger and more intricately related phenomena can only be understood by principles and patterns – not in detail. Complexity deals with the nature of emergence, innovation, learning and adaption." (p. v).

Given unpredictable actors in uncertain systems, perhaps the only thing we can be sure of is that the future is unpredictable and unknowable (Uhl-Bien & Marion, 2008) (Figure 2). Complexity forces managers to look for assets and tools to protect their organizations from unpredictable future threats. Over the last decades knowledge has been deemed the most valuable and critically important organizational asset, one to be consciously and astutely managed (Drucker, 1993, 1985). As a "strategic resource" (Roth, 2003, p. 32), one would expect knowledge to provide managers with the ability to prepare for an unpredictable complex future. The main problem, however, is that the value of knowledge is often restricted in time. In other words, it has a limited shelf life. Knowledge is also restricted to people's ability to assess decision situations, evaluate possible consequences of the decision, and apply knowledge (Intezari & Pauleen, 2019). "Decision situation, or decision-demanding situation, refers to a situation when decision making is inevitable. In the decision situation, the need for a decision is apparent and the decision maker must begin to define the problem and get involved in the decision-making process." (Intezari & Pauleen, 2019, p. 11).

KM advocates claim that organizations' KM systems enhance organizational capacity and ability to capture people's knowledge and use it to deal with market, societal, and political challenges. Hassell (2007) would strongly argue that the outcome of KM systems is just a set of organized data, i.e., 'computerized knowledge'. Organizations' ability to deal with complexity depends on the extent to which people in an organization can apply knowledge. Moreover, as long as knowledge is utterly dependent on experience, information, and previous knowledge, organizations will always be surprised when facing the future. Our experiences do not remove uncertainty (Buckley & Carter, 2004). As Gell-Mann (1990), the winner of the Nobel Prize in physics and one of the founders of the Santa Fe Institute, suggests, the future as a complex nonlinear entity cannot be analyzed by creating a picture through combining a set of features studied in advance: "One of the most important characteristics of complex nonlinear systems is that they cannot be successfully analyzed by determining in advance a set of properties or aspects that are studied separately and then combining those partial approaches in an attempt to form a picture of the whole" (p. 7).

Considering the sources and applications of knowledge, it is paradoxically past-oriented in terms of sources, and future-oriented in terms of implementation. From a KM point of view, knowledge rests in great part on the development of data, information and experience, which implies that making accurate decisions entails gathering, evaluating, and storing enough relevant and accurate data and information. Obtaining the data and information on an emergent event, prior to the occurrence of that event, would appear to be a challenging task for individuals and organizations. However, as mentioned, big data, theoretically and increasingly

Figure 2. Humans' anticipating capacity vs. future unpredictability



in practice, brings access to data to the present moment. And again, theoretically and perhaps in practice, computer analytics are turning the data into information in near real time (Davenport et al., 2013). The field, however, seems to be lacking empirical data showing whether this big data/analytic-based information is being used in emergent management decision making and if so, how?

The researchers are not arguing that knowledge is rigid or inflexible, particularly if knowledge is considered as an embodied quality. The researchers acknowledge that knowledge has a dynamic nature that allows it to evolve over time. The paradoxical dimensions of knowledge (past-basis versus future use) are based on two suppositions. The first supposition is that knowledge is based on accurate and useful data, information and experience, and also that a decision maker thoroughly understands a given situation and what data, information and experience are needed to make a decision. As mentioned, acquiring accurate and timely information is difficult, but equally challenging for a decision maker is being able to filter out cognitive bias, pressure and stress to get a clear understanding of a situation and the available information (Intezari & Pauleen, 2014; Liew, 2013). The second supposition is associated with the 'implication' of knowledge, i.e., its intended use. Despite knowledge being rooted in the past, the objective of knowledge is to improve human life at a given time whether in the present or the 'after-now'. In this sense, knowledge is future-oriented in application.

In dealing with the future, these two aspects of knowledge cause no problem insofar as circumstances are predictable and similar to the events experienced in the past. But due to the non-linear, multi-causal, socio-politically complex and interwoven nature of the business world, the future is by no means completely predictable. Any simple action and decision may lead to unintended consequences. The situations a decision maker confronts in the future may or may not be a continuance of past and current trends. Accordingly, the acquisition of knowledge – whether through gathering data and information, or by experience – prior to the occurrence of an emergent event is enormously challenging for managers. Unpredictable events or situations, such as the Deepwater Horizon oil spill in the Gulf of Mexico, may be something completely new with surprising emergent characteristics and dimensions.

While it is possible to some degree to predict the former and to cope with it accordingly using one's knowledge, the latter is more likely to go beyond one's knowledge and experience and therefore be difficult to deal with. This anticipating capacity declines as the level of volatility and unpredictability of the business environment increases.

The subjectivity of knowledge (Kramer, 1990), and the relativity and fragility of human perception (Intezari & Pauleen, 2014; Rooney et al., 2010; Vahid, 2008) are the other reasons for not depending solely on data and information. The concurrent fallibility of the knowledge at hand and fragility of humans' perception to capture real key aspects of a given emergent event makes it a challenging task for managers to make decisions that are appropriate for the circumstance at hand, especially when timely and effective decisions are required. But, how can it be assured that one's past knowledge will be useful when one is facing emergent events? In other words, how can knowledge be transformed into the kind of knowledge that is more suitable for dealing with emergent phenomena? What is the role of knowledge in a complex world for coping with emergent phenomena? Is knowledge only for simplifying complexity?

As Snowden and Boone (2007) state, although simplification may be applicable in ordered situations, in more complex contexts simplification may fail. So, as suggested in the next section, differentiating informed actions from wise actions may provide insight into the query. It will be discussed that wisely made decisions can lead to innovative outcomes in emergent situations that may enhance the chance of success in unpredictable business circumstances.

Looking Beyond Analytics and Accumulated knowledge

"A better future [than the one resulting from relying completely on limited cognition, relative knowledge, perception and truth] is possible if we look beyond the accumulative assumptions about knowledge (and technology) to wisdom" (Rooney et al., 2010, p. 17).

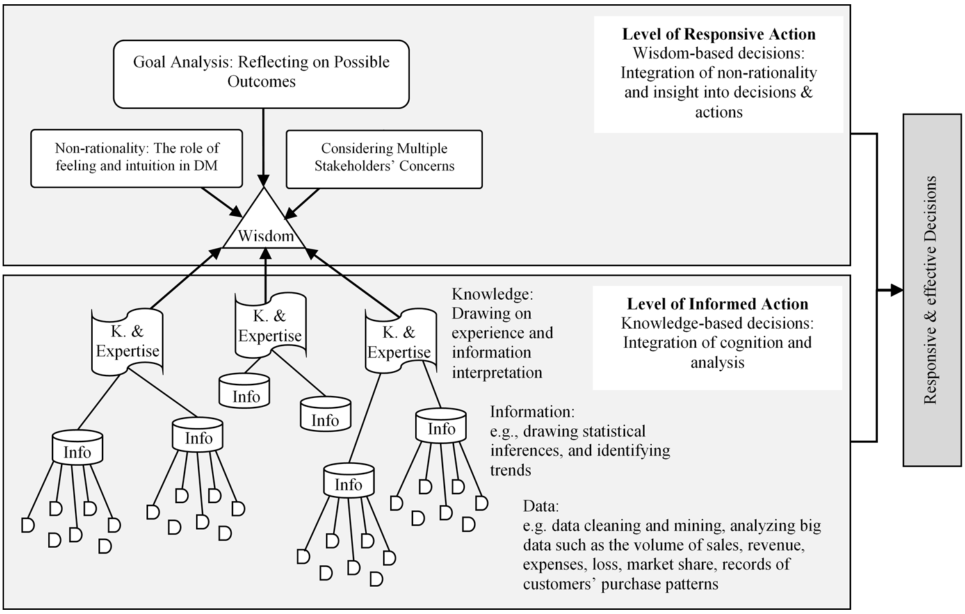
Complexity and unpredictability are the main issues managers face in the current unstable business environment. Good judgment, effective decision making, and innovative and proper action are essential to organizations in all situations, especially when facing unanticipated circumstances. What must be considered as a matter of great concern to organizational leaders and those who are involved in organizational learning is that concentrating on managing knowledge only, as is currently the fashion, may not necessarily lead them to wise judgment, good decisions and appropriate actions.

Knowledge management, and other subjects from the management literature such as organizational learning (*cf.* Küpers & Pauleen, 2015), needs to shift from only analyzing data accumulated in the past as well as the diffusion of vast amounts of information, to an integrated approach focusing on the development of both knowledge and wisdom (see Figure 3). This integrated approach, bringing such factors as reflection, non-rational cognitive abilities, judgment, and the consideration of multiple stakeholders into the equation, emphasizes that when dealing with complexity, informed decisions and actions must incorporate wisdom aspects.

KM systems and how well one manages knowledge play critical roles in dealing with complex multi-causal problems. But what may matter more is the way that situations are judged, and how available data and information are analyzed and integrated with insight towards the goal of making effective decisions. Having "the ability to identify the salient features of complex and particular situations" as Roca (2008, p. 610) defines Aristotle's concept of *phronesis*, is crucial for individuals, groups, and organizations. Wise decisions and actions are based on intellectual and moral virtues. Intellectual virtues are wisdom as a cognitive process (Csikszentmihalyi & Rathunde, 1990), which is associated with data and information analysis, while moral virtues are more associated with such attributes as justice, temperance, and courage (Begley, 2006), and with considering stakeholders' concerns, values, and preferences (Intezari, 2014). Intellectual and moral virtues are the two main aspects of wisdom (Ardelt, 2011; Rooney et al., 2010). Virtue, according to Aristotle, is concerned with the answer to the question "How should I act in this particular situation I am situated in?" (Francis, 1990, p. 5). Leading to action, in fact, is the key to why wisdom is a virtue. Csikszentmihalyi and Rathunde (1990) clarify this, writing: "wisdom is a virtue because by relating in a disinterested way the broadest spectrum of knowledge, it provides the most compelling guide to action" (p. 48). Being 'practically wise' harmonizes the two virtues (Roca, 2007).

While rational and intelligent acting falls short of embracing wisdom concepts such as non-rationality, discourses and spirituality (Izak, 2013), wisdom allows for the integration of both rationality and nonrationality into decision-making. Wise decisions are informed decisions and actions that are based on reliable and relevant data and information. At the knowledge level (the lower part of Figure 3), the quality of decisions is likely to be compared with others by assessing the quality of the data and information, how they are gathered, and the way the data and information

Figure 3. Informed and wise actions (adopted from Intezari & Pauleen, 2017)



are analyzed (methodological rigor and validity). However, wisdom brings into consideration other factors such as 1) multiple stakeholders, 2) the role of intuition, feelings, and prior knowledge, and 3) analysis of possible consequences of a decision in order to compare and enhance the quality of a decision or actions (Figure 3).

The link between innovation and wisdom in dealing with uncertain and turbulent business circumstances is the *cognitive process*. The cognitive process refers to attempts made by the decision maker to understand the world "in a disinterested way, seeking the ultimate consequences of events as well as ultimate causes while preserving the integration of knowledge" (Csikszentmihalyi & Rathunde, p. 48). The cognitive process provides conceptual and operational representations that practitioners develop as they interact and deal with complex systems (Tikkanen et al., 2005). Both the process and the result of being wise in facing a complex and unpredictable future are likely to be innovative. Being able to develop innovative ideas and solutions is what 'coping with unpredictability' is about. Uncertainty bounds rationality (Potts, 2010) and previous knowledge, experiences, and solutions may not be sufficient for handling emergent situations; innovative ideas through a practical wisdom-based cognitive process enable business people to deal with complexity. As illustrated in Figure 3, an innovative outcome results from a process that begins with preexisting knowledge which is created based on experience, data, information, and prior knowledge. Through a cognitive process, wisdom helps individuals to more accurately articulate and gain a rigorous understanding of the decision circumstances. Wisdom leads the acquired understanding of the decision's circumstances towards sound judgment by bringing both individual and organizational beliefs and values into consideration. This capacity for creativity and generating new insights by reformulating and re-conceptualizing what is already known is, according to Rooney et al. (2010), a fundamental part of wisdom.

Following an accurate judgment, wise action would be more likely to lead individuals and ultimately organizations to more effectively influence the consequences of their actions. Individuals are at the coalface, closest to the action. Being able to make accurate judgments and decisions and to take wise actions will allow the organization to have greater influence over the consequences of their decisions and to achieve innovative results when faced with complexity and emergence.

Emergent situations, at the level of the individual, are defined as being the circumstances in which individuals have to make decisions in real time using their cognitive abilities and judgment skills independently, to some extent, of their supervisors to handle uncertain and unforeseen situations. At this level, wisdom mediates between beliefs, values, knowledge, information, abilities, and skills (Sternberg, 1990). At the organizational level, an emergent situation can be a financial crisis that requires a quick yet proper organizational reaction.

Knowledge is connected to judgment and reflection (Strati, 2007), qualities that are extensively dealt with in the realm of wisdom. Knowledge judges information and refines itself in new situations (Davenport & Prusak, 1998) and wisdom helps individuals find out how appropriate knowledge can be effectively chosen and applied in specific situations (Bierly et al., 2000), as well as how new ideas are developed and used wisely. In this sense, wisdom reconciles what is in mind with what emerges in action. As Rooney et al. (2010) put it, "wisdom is concerned less with how much we know and more with what we do and how we act" (p. 17). This means that through applying wisdom at this level, both one's explicit and tacit knowledge will come together. Explicit or codified knowledge refers to what people know and are aware of. Explicit knowledge is transmittable in formal and systematic language, while tacit or implicit knowledge is difficult to codify and share (Nonaka, 1994). Tacit knowledge is rooted in action, commitment, ideas, procedures, routines, values and emotions (Nonaka & Krogh, 2009) and gained through practical experience (Insch et al., 2008).

At the individual level, wisdom relies on personal abilities and skills to make sound judgments and right decisions. Although individuals comprise teams and groups, groups are wiser than their collective individual members (Mannes, 2009), and new ideas need to be adopted by others to become an innovation (Potts, 2010). This way, groups and their interactions, playing an important role in promoting wisdom from the individual level to the organizational level, lead organizations to innovative thinking and wise action.

A wise organization cannot exist without wise individuals and an organization requires wise people at all organizational levels. Wisdom, derived from wise members and wise groups, encouraged, collected, collated, and directed by the organization will result in appropriate organizational action and innovative outcomes in the face of emergent and complex situations.

CONCLUSION

In this chapter the researchers asked the questions, to what extent can organizations trust their information, experience and their previous knowledge to prepare for future circumstances and what can assist them when facing future situations never seen, experienced or possibly imagined? The researchers presented an extension to the understanding of knowledge as proposed by KM and concluded that when faced with complex situations where emergence and unpredictability are the main challenges, the volume and velocity of data, information, and accumulated knowledge computerized by KM systems and how well one manages that knowledge *does* matter. But what may matter more is the way that situations are judged, available data and information are analyzed and integrated with insight towards the goal of making effective decisions. Real knowledge management is not possible without community (Hassell, 2007) and twenty-first century organizations need to be capable of going beyond experience and knowledge to perceive the volatile world as it is and to introduce innovative ideas according to the reality of the environment if they are to survive in situations where events occur only once or for the first time.

Knowledge repositories will still be very useful mainly when dealing with semi-/routine tasks, where the demand for situational and value-laden judgments is not very high. As this chapter suggests, organizations still need to: 1) develop reliable knowledge repositories, consistent with contemporary approaches to KM; 2) keep people in the organization, not just their knowledge; and 3) ensure that their people, through analytical reflection, are able to turn data and information into effective decisions and actions.

People in organizations must have training opportunities to enhance their capacity for sound judgment, reflection, and multi-perspective considerations. People need to be able to identify problems, articulate probing questions, assess alternatives, and judge possible outcomes and consequences of decisions and actions. Knowledge management systems need to be designed in such a way that directs people with questions not just to data or information repositories, but also to people who may not have the right answers but who certainly have the ability to approach questions with wisdom. Effective knowledge management systems will be the ones that offer features to enhance the user's capability for judgment and decision making.

With this chapter, the researchers point the way toward both better practice and further research. For organizations we suggest that the value of knowledge and knowledge management, while critical to organizations, must be understood as only a partial response to future operational and strategic planning. In addition, leaders and managers must be able to tap into and further develop a 'wisdom' response at all levels of the organization to satisfactorily manage complex environments and future contingencies. For researchers, those individuals and organizations that have not shied away from applying wisdom, insight and innovative thinking in the day-to-day management and leadership of their organizations need to be located and documented. The more cases are illuminated the more likely these qualities will become a routine part of 'doing business'.

As discussed in this chapter, handling the current complex business world requires both analytics and insight. Effective decisions require an integrative approach to the data and information available, and the qualities that enable the decision maker to reflect not only on past and current experiences, data, and information, but also on the possible consequences of their decisions. It is suggested that future studies in knowledge management and wisdom management investigate how knowledge and information management systems can be designed and implemented in such a way that supports integrated decision making, bringing together both analytics and insight.

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KEY TERMS AND DEFINITIONS

Decision Situation: "Decision situation, or decision-demanding situation, refers to a situation when decision making is inevitable. In the decision situation, the need for a decision is apparent and the decision maker must begin to define the problem and get involved in the decision making process." (Intezari & Pauleen, 2019, p. 11).

Emergent Decision Situations: The manifestation of new phenomena or events that are sometimes impossible to predict. These are circumstances that an organization or manager may not have experienced before and for which their knowledge may be irrelevant or inadequate.

Knowledge Implementation: An embedding process through which knowledge is incorporated into products and services to gain competitive advantage.

Turbulent Business World: A business environment replete with numerous emergent phenomena.

Wise Decisions: Wise decisions are informed decisions and actions that in addition to reliable and relevant data and information, take into consideration other factors such as 1) multiple stakeholders, 2) the role of intuition, feelings, and prior knowledge, and 3) analysis of possible consequences of the decision in order to compare and enhance the quality of the decision or action.

Section 2

Application of Advanced KM

Chapter 9
E-Collaboration in Virtual Teams:
Trust as a Facilitator of Development

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ABSTRACT

This chapter examines the relationship between task-communication and five collaborative processes by exploring the mediating effect of interpersonal trust in a virtual team's environment. First, a multiple mediation model was developed to examine this relationship where cognitive-based trust and affective-based trust are defined as mediation variables between task-communication and five processes of collaboration. Then, employing qualitative thematic analysis, authors constructed a conceptual model to identify factors that generate lower or higher level of collaboration. The main results of this study show a significant correlation with a large effect size between task-oriented communication, trust, and collaboration. Also, interpersonal trust is playing an important role as a mediator in the relationship between task-oriented communication and collaboration, when the emotional side of trust is no less important than the rational side, if not even more, in some collaborative processes.

DOI: 10.4018/978-1-7998-2355-1.ch009

INTRODUCTION

With the development of the communication technologies of the last decades, the world transformed into a global village. These communication technologies, such as the Internet revolution of the 90s and the mobile revolution on the recent years, have provided the necessary infrastructure to support the development of new organizational structures. One of the changes that this revolution brought to organizations is the creation of a new kind of team engagement, in addition to the conventional face-to-face team: the virtual or distributed team. Thanks to information and communication technology systems, these teams can communicate, work together, share knowledge, solve problems, and make decisions across the globe.

However, these virtual teams have created new challenges for organizations. One of these challenges is the lack of interpersonal relationships based on face-to-face communication and not technology-mediated. This lack may affect the level of trust within the teams, which is depending on interpersonal relationships and critical to the proper functioning of the teams.

Better understanding of the impact of the communication and trust on collaboration process in virtual team is the main contribution of this study. The results of the research can help organizations to increase their efficiency, their performance and their quality of outcomes, enabling organizations to be more competitive.

This paper examines the interrelations between task-oriented communication, trust and collaborative processes. Following, a review of the relevant literature, a presentation of the methodology and an outline of the research findings. Subsequently, discussion of the study results by reference to previous research and reflect on their relevance for management practice and future research.

LITERATURE REVIEW

There are several definitions in the literature for virtual teams. Virtual teams have been commonly defined as functioning teams that rely on ICT-mediation that crosses several boundaries (Bell & Kozlowski, 2002; Kirkman et al., 2002; Peters & Manz, 2007; Ebrahim, Ahmed, & Taha, 2009). It is widely agreed by scholars, that the main element that defines virtual teams is its composition of individuals who communicate and are dispersed across space, time, and/or organizational boundaries (Peñarroja et al., 2015; Huang, 2010). Thus, a working definition of virtual teams is distributed work teams whose members are geographically dispersed and coordinate their work predominantly with electronic information and communication technologies (ICTs) (Hertel, Geister, & KonrFadt, 2005).

Duarte and Snyder (2011) identified communication and collaboration as two of the most important factors in teams' success. Schultze and Orlikowski (2010) noted that the virtual setting has been shown to be a promising and powerful environment for team performance. However, virtual teams, because of distances separating the team members, need to develop ways to create successful collaboration. The availability of e-collaboration tools, such as social networks, wiki, and collaborative sharing files (e.g., Google Docs and Office 365), video conference (e.g., Skype) can contribute to this effort (Hosley, 2010; Kauffmann & Carmi, 2014).

Communication

Communication is an important process for any team. However, this is particularly true for virtual teams (Thomas, 2010; Roth, 2010). Communication is not only an important process, it presents a considerable challenge in a virtual environment, often involving different time zones, cultures, as well as distance (Mumbi, 2007). The lack of physical contact makes it more difficult to establish the strong relationships and bonds that lead to high levels of trust, thus making the communication process more difficult (Grabner-Krautera & Kaluschab, 2003).

Task-oriented communication has been investigated in several studies dealing with proper team functioning (e.g., Huang, 2010; Lau, Sarker, & Sahay, 2000; Jarvenpaa & Leidner, 1999). Task-oriented communication focuses on how well project information, tasks, and deliverables are being handled through the communication. In other words, it moves the teams forward in the accomplishment of their task. It includes communication such as planning and scheduling of work, coordinating subordinate activities, and providing necessary supplies, equipment, and technical assistance (Yukl, 2012).

Trust

Team trust is function of other team members' perceived ability, integrity, and benevolence, as well as of the members' own propensity of trust (Mayer, Davis, & Schoorman, 1995). In order to trust, and thus to rely on another party, to take risks, and to be vulnerable, - teammates must create effective social and interpersonal relationships with each other (Jones & George, 1998; Mayer, Davis, & Schoorman, 1995; McKnight, Cummings, & Chervany, 1998).

Based on the concept that trust may have rational and emotional roots, a model of cognitive and affective dimensions in trust has been developed by McAllister (1995). When trust is based on cognition, individuals use rational thought in order to trust others. Cognition-based trust refers to performance-relevant cognitions such as competence, responsibility, reliability and dependability (Schaubroeck, Lam,

& Peng, 2011). But when the interaction between team members is intense, the emotional and mutual investment in the relationship becomes primordial; this is where the affective side of trust comes into play (Erdem & Ozen, 2003). The emotional attachment created by this intense interaction emphasizes empathy, affiliation and rapport, based on a shared regard among team members (Schaubroeck, Lam, & Peng, 2011). Therefore, to maintain trust in the long run, the affective aspect of the relationship must be developed (McAllister, 1995). In light of this, even if high levels of trust at an early stage are possible, and may be driven by cognitive cues from group membership and reputation, affective trust has to be develop later in the life of interpersonal team relationship (Williams, 2001). In sum, cognitive and affective dimensions of trust are often tightly intertwined in work relationships.

Collaboration

Collaboration among teamworks is an essential ingredient to the success of organizations (Boughzala, de Vreede & Limayem, 2012). Many of them organize training and seminars to their teams on a periodical base in order to increase the level of collaboration. Collaboration can create outcomes that cannot be achieved by an individual alone (Peters & Manz, 2007). Collaboration is a complex process, which, because of communication and interaction between parties, creates relationships between them. It allows sharing and synchronizing information for the purpose of decision making and achieving common matters or goals (Hosley, 2010). In general, collaboration results from a need to solve a problem, create, or innovate (Peters & Manz, 2007). It is defined as a process in which autonomous actors interact, through formal and informal negotiation. They jointly create rules and structures governing their relationships and ways to act or decide on the issues that brought them together. It is a process involving shared norms and mutually beneficial interactions (Thomson & Perry, 2006). We identified five common collaborative processes complementing each other (Bell & Kozlowski, 2002; Osman, 2004; Casalini, Janowski, & Estevez, 2007; Turban, Liang & Wu, 2011; Evans, 2012; Atteya, 2013; Ghaznavi et al., 2013).

Following, the definitions of each of the five common collaborative processes as reflected in the literature.

1. Knowledge sharing is defined as the willful application of one's ideas, insights, solutions, and experiences to another individual, either through an intermediary, such as a computer-based system, or directly (Turban et al., 2006). Hence, collaborative knowledge sharing can play a critical role in bringing together the knowledge, experience, and skills of multiple team members to contribute to team development more effectively than can individual team members performing their narrow tasks (Kumaraswamy & Chitale, 2012).

2. Conñict management is deðned as behavior oriented toward intensiðcation, reduction, and resolution of tension, which may generate an opportunity to improve situations and strengthen relationships (Ayoko, Ashkanasy & Jehn, 2014). Collaborative conflict management refers to a mechanism by which all parties can address their desires, with neither side having to sacrifice considerably (Paul et al., 2005).
3. Problem solving is defined as a process used to obtain the best answer to unknown situations or to take a decision subject to some constraints (Mourtoset et al., 2004). Collaborative problem solving is done by peers, performing the same actions, having a common goal, and working together (Dillenbourg, 1999).
4. Decision making is defined as a group's ability to integrate information, use logical and sound judgment, identify possible alternatives, select the best solution and evaluate the consequences (O'Neil, 1999). Collaborative decision making typically evolves from either formal or informal deliberations in groups, where the group members consider and debate various possible decision alternatives. The issue to be decided is resolved through discussions, where argumentative logic and persuasive presentation are critical (Raghuet et al., 2001).
5. Innovation is defined as a dynamic process through which problems and challenges are defined, new and creative ideas are developed, and new solutions are selected and implemented (Sørensen & Torfing, 2012). Collaborative innovation is recursive interaction of co-creativity, knowledge, and mutual learning between two or more people working together toward a common goal, generating new sources of growth or wealth in an organization (Lynch, 2007).

Communication and trust have often been acknowledged as critical components for team collaboration building (Barczak, Lassk & Mulki, 2010). As collaboration relies on the presence of trust, shared vision, and communication (Mattessich, Murray-Close, & Monsey 2001), it requires a dynamic relationship across various members and groups, particularly in virtual teams. Trust and communication are likely to facilitate this dynamic relationship.

Communication, Trust, and Collaboration

Studies examining the linkages between communication, trust, and collaboration are abundant. Most of these studies have tended to focus on associations between communication and trust (Jarvenpaa & Leidner, 1999; Zeffane, Tipu & Ryan, 2011). Additional studies focused on linkages between other pairs, such as communication and collaboration (Mattessich, Murray-Close, & Monsey, 2001; Qureshi, Liu & Vogel, 2006; Hosley, 2010) and trust and collaboration (Peters, 2003; Peters & Manz, 2007; Martínez-Miranda & Pavón, 2012). However, to the best of our knowledge, only the most recent studies have considered the three variables together, albeit not examining the relationship between them (Roth, 2010; Thomas, 2010; Morita & Burns, 2014).

Communication and Trust

Communication plays an important role in the development of trust in virtual environments. Several studies hypothesized and concluded that communication affects trust formation. For example, Erturk's (2008) study showed a correlation between communication within a team and trust in the team leader.

A strong positive correlation between trust and communication was also observed in a study exploring the associations between communication, commitment, and trust in an organization (Zeffane, Tipu & Ryan, 2011). They held that besides communication being closely related to trust, communication serves as a major predictor of interpersonal trust. Javenpaa and Leidner (1999) also observed that in a global virtual team, trust would more likely be established by means of a communication behavior, especially task-oriented communication.

Communication and Collaboration

The literature provides evidence that the quality of communication affects team collaboration and performance. These influences can be positive or negative, depending on channels and types of communication. Research findings have shown that communication is a fundamental element associated with virtual team collaborations (Mattessich, Murray-Close, & Monsey, 2001; Hosley, 2010). Moreover, Qureshi, Liu, and Vogel (2006) found that effective collaboration is an outcome of successful communication in virtual teams. For them, effective communication can improve and optimize knowledge sharing, problem solving, conflict management, decision making, and innovation.

Other research findings have shown that for knowledge to flow effectively among virtual team members as a part of the collaborative process, a high level of communication is necessary (Hosley, 2010). Likewise, Osman (2004) claimed that one of the antecedents for innovation is the need for communication to transfer knowledge across the virtual team. In addition, other researchers concluded that with extensive communication, analysis, deliberation, and negotiation, team members can work together to analyze and prioritize alternative solutions to problems and determine the preferred option (Turban, Liang, & Wu, 2011). In their view, group decision making comprises a series of activities that require interaction and communication, such as deliberation, posing questions, and collecting responses.

Trust and Collaboration

Trust has been identified by several scholars as a fundamental aspect of effective collaboration. The impact of trust has been tested according to several performance variables, such as level of collaboration, quality, and timeliness. The variable most affected by trust was level of collaboration (Martínez-Miranda & Pavón, 2012). The association between trust and collaboration has also been examined in virtual environments, confirming the important role of trust in promoting collaboration (Peters, 2003). Peters and Manz (2007) also concluded that in virtual team environments, collaboration can only occur if team members are willing to create dependencies. These will be exploited only in the presence of trust within the team.

Some studies have shown that trust has a direct impact on team functioning (Haines, 2014; Schiller et al., 2014), while others maintaining that trust functions only as a moderating-mediating factor (Peñarroja et al., 2015; Fransen, Kirschner, & Erkens, 2011). Thus, Brahms and Kunze (2012) developed and validated a moderated model that explains the indirect relationship between team goal setting and performance transmitted through task cohesion, which is dependent on the level of trust climate. A study (Goodwin et al., 2011) on the relationship between leadership and some organization outcomes, test the role of trust as a moderator or a mediator in the relationship. The study did no support for the role of trust as a moderator. However, trust fully mediated the relationships between them. Peters and Manz (2007) developed a conceptual model, where the relationship between developed relationships and degree of virtual collaboration is at least partially mediated by trust. And finally, an additional conceptual model has been proposed by Kauffmann (2015), arguing that trust mediates the relationship between communication and collaboration. This last conceptual model was used as a part of this study framework where trust play a mediation role.

Although, five common collaborative processes have been identified in the literature, many studies have related to collaboration as a global construct without disassembling it or have investigated only a single process, independent of the collaboration concept. To our knowledge, no study of virtual teams has included the five common collaborative processes in a single study.

Thus, the contribution of the current study is in its offering a high-resolution understanding of the collaborative process through the influence of both cognitive-based trust and affective-based trust on each of the five identified processes.

Consequently, the present study empirically tested a mediating model, considering trust as catalyst of the communication factors that in turn enhance virtual team collaboration. In addition, disassembling collaboration to five complementary processes may facilitate increasing team efficiency, performance, and the quality of outcomes, with the goal of becoming more competitive and creative.

The study model claims that trust functions as a mediating factor between task-oriented communication and collaborative processes. This claim is based on the argument that trust is a mediator factor and that all the three components—communication, trust, and collaboration—are linked: (1) communication to collaboration (Qureshi, Liu & Vogel, 2006; Hosley, 2010); (2) trust to collaboration (Trainer, 2012; Martínez-Miranda & Pavón, 2012); and (3) communication to trust (Roth, 2010; Thomas & Bostrom, 2008).

METHODOLOGY

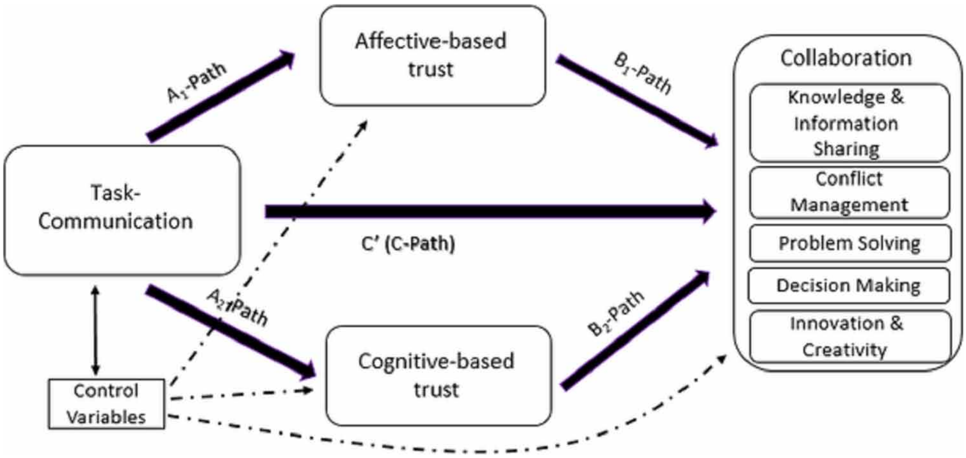
Research Question

The research question is divided into two main questions. The first one is quantitative where the study aim to define if cognitive- and affective-based trust play a role between the level of task-oriented communication and the five collaboration processes. The second one is qualitative and aim to determine why do virtual teams need to build and develop trust for task-oriented communication to be more effective. This second question will help us develop a conceptual model to identify factors causing a low level of collaboration due to lack of trust in communication and those contributing to high levels of collaboration through trust in communication.

Research Method

The aim of this study is to obtain a better understanding of the e-collaboration processes in virtual teams by analyzing trust impact on the relationship between task-oriented communication and five of the common collaborative processes. Some virtual teams have difficulties or are failing to reach their objectives due to poor communication between the team members. First, we have developed a mediation model and tested it empirically in order to discern factors that can positively influence the quality of this communication and increase e-collaboration. Then, through the qualitative analysis of interviews, sought to understand the reasons behind the obtained findings. This study's findings will contribute to the construction of a conceptual model, pursuant to the type of e-collaboration processes. The mixed-method used in the current study was explanatory sequential design, a methodology appropriate for cases where qualitative data is required to explain the mechanism of significant or insignificant quantitative results.

Figure 1. Research model



Research Model

The proposed mediation model relates the variables investigated in the present study (see Figure 1). A mediation model enables an assessment of how and under what conditions a given effect is produced. The study model suggests that the effect of task-oriented communication on collaborative processes will be more likely to occur in virtual teams that have a high level of team trust. When a team trust climate is present, team members are more willing to collaborate freely, without being concerned with the threat of negative reactions of team members to embarrassing or awkward errors.

Accordingly, the following hypotheses are proposed:

H1a: Cognitive-based trust mediates the relationship between task-oriented communication and knowledge sharing.
H1b: Affective-based trust mediates the relationship between task-oriented communication and knowledge sharing.
H2a: Cognitive-based trust mediates the relationship between task-oriented communication and conflict management.
H2b: Affective-based trust mediates the relationship between task-oriented communication and conflict management.
H3a: Cognitive-based trust mediates the relationship between task-oriented communication and problem solving.
H3b: Affective-based trust mediates the relationship between task-oriented communication and problem solving.

H4a: Cognitive-based trust mediates the relationship between task-oriented communication and decision making.
H4b: Affective-based trust mediates the relationship between task-oriented communication and decision making.
H5a: Cognitive-based trust mediates the relationship between task-oriented communication and innovation and creativity.
H5b: Affective-based trust mediates the relationship between task-oriented communication and innovation and creativity.

QUANTITATIVE RESEARCH

Quantitative Research Sample

The final sample consisted of 259 participants (from a total of 350, who were invited to participate) from all over the world, except Africa (106 from North America, 3 from South America, 68 from Europe, 72 from Asia, and 10 from Australia). The study was tested on several companies and was not limited to a specific one. Usually, studies employed the convenience sample, where they have selected a group of individuals or have chosen several virtual teams to survey. As a consequence, the results are limited to the specific group or team selected by the researcher. This study aims to be a baseline for the model. Thus, maximum variation sampling was chosen for this study. The main principle behind maximum variation sampling is to gain greater insights into a phenomenon by examining it from several angles. Therefore, most of the respondents worked in high-tech companies (e.g., electronics, software, communication, hardware, and services), with the rest from finance, health care, marketing, and service industries.

Among the participants, 34.7% were women and 65.3% men; 17% of the participants worked in temporary virtual teams and 73.7% in ongoing virtual teams, with the remainder working in both temporary and ongoing teams. Likewise, 20.8% defined themselves as belonging to a local virtual team, 36.7% to a global virtual team, with the remainder defining themselves as belonging to both kinds of virtual teams. Finally, 39% defined themselves as team leaders, 49% as team members, with the remainder have roles of team leader or team member, depending on the project. A web survey was designed and distributed to groups working in a virtual environment through the social media of LinkedIn and Facebook.

Quantitative Measurement

For this study, cognitive-based trust and affective-based trust were assessed utilizing modified survey items originally developed by McAllister (1995). Each of the two variables was assessed by five items. Task-oriented communication was assessed by a four-item questionnaire (Kauffmann & Carmi, 2014). The five collaborative processes were assessed by items adopted from other studies: Knowledge Sharing was measured by three items (Samarah, 2007). Conflict Management (Tjosvold, Chen& Yu, 2003), Problem Solving (Van de Viert, 1997), Decision Making (Samarah, 2007), and Innovation and Creativity (Peters, 2003) were assessed by four items each. Cronbach's α was calculated for each of these variables (Table 1), with all values surpassing .8. All items were presented on a 5-point Likert-type scale, ranging from 1 ("I strongly disagree") to 5 ("I strongly agree'').

Following some example of items used in the study questionnaire. An example of item for cognitive-based trust: "Generally, the team members approach their job with professionalism and dedication". For affective-based trust: ”I can talk freely to a team member about difficulties I am having at work and known that s(he) is willing to listen". An example of item related to the task-oriented communication: "Team members report their work progression and update scheduled tasks status". Related items which used for the five processes. For Knowledge Sharing: "Team members are willing to explain to others certain aspect of team's tasks". For Conflict Management: "We work so that to every extent possible we all get what we really want". An example of item used for Problem Solving: "Team members examine issues until a solution is found that really satisfies all members". For the Decision-Making variable: "I am confident that the final decision made by my team was the best decision". And finally, an example for Innovation and Creativity: ”My team demonstrates originality in its work".

The process of validating the questionnaire comprised two stages. First, it was send to five colleagues to examine the questions and their structure, indicating suggested improvements. As a result of their comments, improvements in the formulation of questions as well as grammatical modifications were made. Second, 25 participants completed a sample test, with Cronbach's alpha calculated for the measurement of the internal consistency. These results warranted other modifications to the questionnaire. With the Likert scale comprising a non-parametric measurement technique and because all the statistical analyses in this study were based on parametric techniques, such as Pearson correlations and simple/multiple linear regressions, all the variables were tested according Murray's (2013) methodology to determinate the compliance of the variables for parametric techniques. Based on this methodology, parametric and non-parametric correlation techniques (i.e., Pearson *r* and Spearman *rho*) were used to test whether similar results are observed. The study showed very similar results in both the level of significance and the strength of the relationship. According to the results, parametric techniques can be used for the data analysis of the Likert scale data, with no concern of reaching incorrect conclusions.

To examine if the items met the requirements of factor analysis, three statistical tests were conducted in SPSS: Cronbach's alpha if an item was deleted, corrected item-total correlation, and factor loading. The Kaiser–Meyer–Olkin measurement showed acceptable results (KMO = .9), and Bartlett's test was significant ($p < .001$). Hence, both tests indicated that the factor analysis was appropriate to the study. As a result of the Cronbach's alpha If item deleted test, one item was deleted from the knowledge-sharing variable. All the variables' items met the corrected item-total correlation requirement with a value above .3 (Field, 2009). Finally, all the variables' items met factor-loading requirement with values of above .32 (Stevens, 2002), based on 259 respondents.

Quantitative Analysis Method

First, all variables were tested for parametric assumptions (e.g., normal distribution, homogeneity of variance, linearity, and multicollinearity) to avoid inaccurate results, reflecting a Type I or Type II error, or the over- or under-estimation of significance or effect size (Field, 2009). Hence, several key assumptions were tested and after some data corrections, all the assumptions were met. Skewness and Kutosis test was used to identify data to be corrected. Four significant outlier observations were found with the test and were corrected by changing their value to get to recommended value for a Z-score of 1.96 (Field, 2009). The study's data can be considered with a high level of confidence as reliable for the parametric tests of this study.

To test for mediation effect, the first step was to find evidence that there is a significant relationship between the independent variable, the dependent variable, and the tested variables for mediation (Baron & Kenny, 1986). This evidence was tested with the use of Pearson's correlation.

Then, to demonstrate the existence of mediation effect, a methodology developed by Preacher and Hayes (2008) was employed for mediation testing that facilitates estimation of the indirect effect with a normal-theory approach and a bootstrap approach to obtain confidence intervals. Simple and multiple regression analyses were conducted to assess each component of the proposed mediation model. In the present study, the 95% confidence interval of the indirect effects was obtained with 5000 bootstrap resamples (Preacher & Hayes, 2008).

To compare the β strength between the results, standardized values (Z-scores) of the variables were used in simple and multiple linear regressions. Two variables were entered as covariates at each of the linear regression analyses. These covariates (or controller variables) comprised the type of virtual team based on time (temporary or ongoing) and on distance (local or global), these distinctions being the most commonly cited in the literature (Kauffmann & Carmi, 2019). Therefore, they were entered as controller variables to test whether they affected the multiple mediation models of this study.

Quantitative Results

Correlation Analysis

Pearson inter-correlations between all the variables were calculated. Moderate to high significant effect size values were found (see Table 1). Therefore, all requirements were met for preliminary mediation effect tests (Baron & Kenny, 1986). This permitted the continuation of the analysis to determine whether affective-based trust and cognitive-based trust had a mediating effect between task-oriented communication and collaborative processes.

Mediation Analysis

In line with our model and the methodology developed by Preacher and Hayes (2008), a mediation analysis was conducted against each of the five collaborative processes (see Table 2). The covariant variables (temporary/ongoing virtual team and local/global virtual team) were found to be insignificant in each of the mediation analysis excepting innovation and creativity for the temporary/ongoing virtual team variable. Consequently, the covariant variables did not affect the mediation models

Table 1. Pearson's Correlation

	1	2	3	4	5	6	7	8
Task-oriented communication	.846^							
Cognitive Trust	.437**	.834^						
Affective Trust	.393**	.571**	.816^					
Knowledge sharing	.465**	.524**	.389**	.887^				
Conflict management	.531**	.585**	.560**	.624**	.873^			
Zscore(SolveProb)	.582**	.610**	.585**	.577**	.716**	.868^		
Zscore(Decision)	.442**	.634**	.557**	.504**	.645**	.676**	.832^	
Zscore(Innovation)	.470**	.443**	.497**	.517**	.496**	.559**	.520**	.863^

** p<.001; ^ Cronbach's α

for four of the collaborative processes. However, for innovation and creativity, the type of team based on time (temporary or ongoing) seemed to affect the model. In this case, further analysis is needed to decipher the effect.

Knowledge Sharing

The results of the mediation analysis confirmed the mediating role of cognitive-based trust (β=.160, CI=.098 to .242) and rejected affective-based trust as a mediator, as it had a result of zero in the confidence interval (β=.027, CI=-.024 to .009). Furthermore, the direct effect of task-oriented communication on knowledge sharing was weaker but still significant (β = .272; $t = 4.330$, $p < .001$) compared to the total effect (β = .459). This last result is suggesting that cognitive-based trust is only a partial mediator of the relationship. The mediating model explained a significant proportion of the variance in task-oriented communication (adj-$R^2 = .351$, $F(7,351) = 22.920$, $p < .001$). The H1a hypothesis was supported where cognitive-based trust was found to be partial mediator. However, the H1b hypothesis was rejected, where affective-based trust seemed to have no impact on the relationship.

Problem Solving

The results of the mediation analysis confirmed the mediating role of both affective-based trust (β=.109, CI=.059 to .178) and cognitive-based trust, as neither had the result of zero in the confidence interval (β=.129, CI=.077 to .198). Furthermore, the direct effect of task-oriented communication on problem solving was weaker but still significant (β = .341; $t = 7.423$, $p < .001$) compared to the total effect (β = .579). This last result is suggesting that trust is only a partial mediator of the relationship. This mediating model explained a significant proportion of the variance in task-oriented communication (adj-R^2=.548, $F(7,351)$=44.559, $p < .001$). Both H2a and H2b hypotheses were supported, where cognitive-based trust and affective-based trust were found to be partial mediators.

Conflict Management

The results of the mediation analysis confirmed the mediating role of both affective-based trust (β=.110, CI=.057 to .185) and cognitive-based trust, seeing as neither had the result of zero in the confidence interval (β=.132, CI=.079 to .204). Furthermore, the direct effect of task-oriented communication on conflict management was weaker but still significant (β = .325, $t = 5.361$, $p < .001$) compared to the total effect (β = .567). This last result is also suggesting that trust is only a partial mediator of the relationship. This mediating model explained a significant proportion of the variance in task-oriented communication (adj-R^2=.505, $F(7, 350)$= 42.126, $p <$ .001). Both H3a and H3b hypotheses were supported, with cognitive-based trust and affective-based trust found to be partial mediators.

Decision Making

The results of the mediation analysis confirmed the mediating role of both affective-based trust (β=.099, CI=.053 to .165) and cognitive-based trust, seeing as neither had the result of zero in the confidence interval (β=.193, CI=.127 to .279). Furthermore, the direct effect of task-oriented communication on decision making was weaker but still significant (β = .182; t = 3.040, p = .003) compared to the total effect (β = .474). This last result is also suggesting that trust is only a partial mediator of the relationship. This mediating model explained a significant proportion of the variance in task-oriented communication (adj-R2=.560, $F(7,348)$=51.549, $p < .001$). Both H4a and H4b hypotheses were supported, with cognitive-based trust and affective-based trust found to be partial mediators.

Innovation and Creativity

The result for cognitive-based trust was very close to a zero result in the confidence interval (β=.062, CI=.004 to .131). Therefore, in addition to the bootstrap test, a Sobel test was run to get a more accurate result. The result of the Sobel test confirmed the doubt, concluding that cognitive-based trust's role as a mediator in the relationship was not conclusive (z = 1.903, p = .057). However, the results of the mediation analysis confirmed the mediating role of affective-based trust, which was without a no-zero result in the confidence interval (β=.110, CI=.053 to .192). Furthermore, the direct effect of task-oriented communication on innovation and creativity was weaker but still significant (β = .282, t = 4.360, $p < .001$) compared to the total effect (β = .455). This last result is suggesting that affective-based trust is only a partial mediator of the relationship. This mediating model explained a significant proportion of variance in task-oriented communication (adj-R^2=.367, $F(7,351)$=18.834, $p < .001$). The H5a hypothesis was rejected, with cognitive-based trust appearing to have no impact on the relationship. However, the H5b hypothesis was supported, with affective-based trust being found to be partial mediator.

All the five multiple mediation hypotheses were fully or partially supported (see Table 3). Two of the five mediation hypotheses were partially supported and three were fully supported. Regarding hypothesis H1, with knowledge sharing as dependent variable, findings showed that only cognitive-based trust was found to have mediating effect on the association with task-oriented communication. For hypothesis H5, regarding the relationship between task-oriented communication and innovation and creativity, only affective-based trust seemed to have a mediating effect on the relationship. All the other hypotheses showed that both affective- and cognitive-based trust had a mediating effect.

Table 2. Mediation analysis of trust on task-oriented communication

		Knowledge sharing	Problem solving	Conflict management	Decision Making	Innovation & Creativity
Total effect	β	.459**	.579**	.567**	.474**	.455**
Direct effect	β	.272**	.341**	.325**	.182*	.282**
Total trust mediated effect	β	.187*	.238**	.242**	.292**	.173*
Affective trust mediated effect	β	.027	.109	.110	.099	.062
	CI	-.024 to .009	.059 to .178	. 057 to .185	.053 to .165	. 004 to .131
Cognitive trust mediated effect	β	.160	.129	.132	.193	.110
	CI	.098 to .242	.077 to .198	. 079 to .204	.127 to .279	.053 to .192
adj-R^2		.351	.548	.505	.560	.361
F(df,df)		22.920* (7,351)	44.559* (7,351)	42.126* (7,350)	51.549* (7,348)	18.834* (7,351)

*p<.01, **p<.001

Table 3. Outcomes summary for collaborative processes hypotheses

Collaborative Hypothesis	Expected Effect	Verification status
H1a - Knowledge sharing	Cognitive-based trust act as mediators in the relationship	Supported
H2a - Conflict management		Supported
H3a - Problem solving		Supported
H4a - Decision making		Supported
H5a - Innovation/creativity		Not supported
H1b - Knowledge sharing	Affective-based trust act as mediators in the relationship	Not supported
H2b - Conflict management		Supported
H3b - Problem solving		Supported
H4b - Decision making		Supported
H5b - Innovation/creativity		Supported

QUALITATIVE RESEARCH

Qualitative Research Sample

Qualitative data collection was derived from a much smaller sample than was the quantitative data in a sequential mixed design, since the objective was not to compare or merge data, but to seek to explain previously gathered data (Creswell & Plano Clark, 2011). A sample of 14 interviewees was selected from the quantitative sample. Four interviewees were virtual team members, six were virtual team leaders and the remaining four were virtual team consultants. Among the 14 interviewees were six women and eight men. The interviewees came from several countries, such as USA, France, Germany, Australia, Austria, Canada, United Kingdom, and Israel.

Questionnaire Design

Based on the results of the quantitative analyses, we sought to understand the sources and the reasons that led to some of the key quantitative findings. Trust has proven to be a significant mediator between communication and the five of the common collaboration processes with exception for cognitive trust with innovation and creativity, and affective trust with knowledge sharing. Identifying the factors generated by lack of trust, as well as those generated by the presence of trust, can help us understand the processes underway and the reasons for these mediations. The questionnaire comprised concept which is well-known to professionals but less familiar to most individuals: mediation. Therefore, it was essential to test the questionnaire to ensure that the question was understood by potential participants. The questionnaire was reviewed by a native English speaker to confirm the clarity of the sentence. Then, the questionnaire was forwarded to three different respondents from the quantitative survey for remarks and/or corrections. Some modifications were introduced to enhance the clarity of the question.

Thus, the qualitative question was formulated as follows: "How do you explain that if communication is not also used to develop trust, the impact of communication on collaboration is negatively affected?"

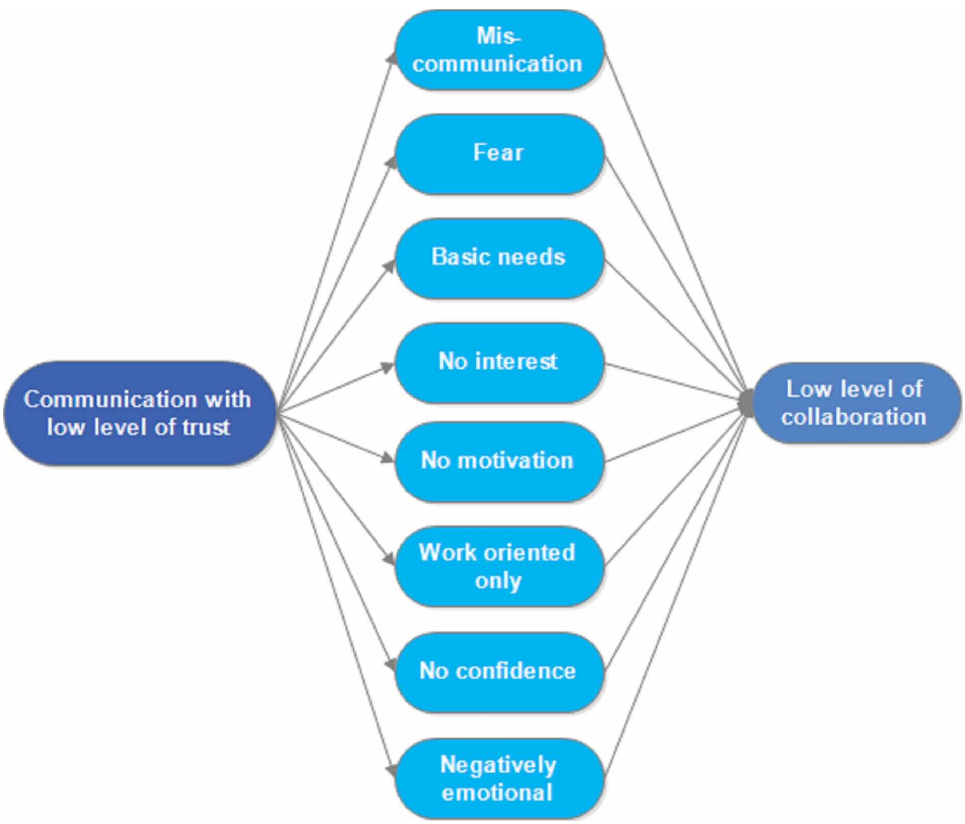
Qualitative Analysis Method

The qualitative method used in the present qualitative study was thematic analysis. This method is a widely used means of analysis in qualitative research. Thematic analysis is a flexible method that can be applied with any theory the researcher chooses. Through this flexibility, thematic analysis allows for rich, detailed, and complex description of the data. After becoming familiar with the data, researchers generate codes that define themes or patterns. There are two primary approaches for identifying these themes or patterns within the data. The first is inductive, where themes are identified directly through the data and are not driven by theoretical interest in the area or topic. The second approach is theoretical, which, in contrast to the inductive mode, tends to be driven by the researchers' theoretical or analytical interest in the area (Attride-Stirling, 2001; Braun & Clarke, 2006). Given the exploratory nature of this study, where the aim of the qualitative phase is to understand more deeply the findings yielded in the quantitative phase, the theoretical method was selected as the thematic analysis approach for the identification of themes. Braun and Clarke (2006) delineated six clear steps for ensuring clarity and rigor in the thematic analysis process. The six steps include (1) familiarizing yourself with your data, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, (5) defining and naming themes, (6) producing the report. We employed these six steps as an analysis methodology for the qualitative analysis and results phase.

Qualitative Results

Firstly, based on the answers of the respondents, the study analyzed the impact of communication that does not include trust between teammates on collaboration quality. The most repeated impact of the lack of trust on teammates is that they will have a low level of motivation and interest in their work. Without trust as an ingredient in communication and " with people you don't know personally, the answers are usually shorter … they (the answers) come later" (respondent 5). If there is no trusting atmosphere then teammates do not have the motivation and personal interest to invest in long and well thought out answers and, they also do not find the time to do it. As argued respondent 12: "One just does not listen so much to people one does not trust". This was also supported by respondent 11 who affirmed that "you simply do not openly communicate with them" and "you tell them only the bare minimum and you don't collaborate with them openly". Moreover, according to respondent 11, the teammates fear having open relationships with their peers which negatively affects the collaboration between them. And when we fear people, "we are less likely to share ideas for fear they will be disregarded" (respondent 3). The lack of trust also has a direct impact on the quality of communication. Without trust, communication could be badly affected and poor-quality communication could be generated. Without a high level of quality of communication, collaboration is negatively affected, as affirmed by respondent 9: "If team members don't work to build trust, misinterpretations of communication often occur and the type of communication can be quite defensive and emotionally based, which negatively affects collaboration". The team members are on guard, if one feels threatened he will react and answer emotionally rather than in a logical and rational manner. Thus, a non-confidence atmosphere is developed within the team, as said respondent 10: "If one is not feeling valued, understood, or included, it is difficult to imagine said individual being trustful and transparent". All this creates a solely work-oriented ambience, creates a distance between the teammates: "Without trust there is no communication but a superior to inferior relationship" (respondent 7). Then there is no place for innovation and progress, as wrote respondent 7: "without any chance of progress or innovation". The team members are focused only on the basic needs of the tasks or project which does not allow the team to evolve and look towards the future: "If there is no trust and no personal relationship, you only respond to direct needs, you solve immediate problems, but you don't go beyond and into the future" (respondent 5). In this analysis, several items were identified as obstacles to reaching a high level of collaboration because of lack of interpersonal trust in the relationship, even if task-oriented communication are present (Figure 2).

Figure 2. Factors generating low level of collaboration

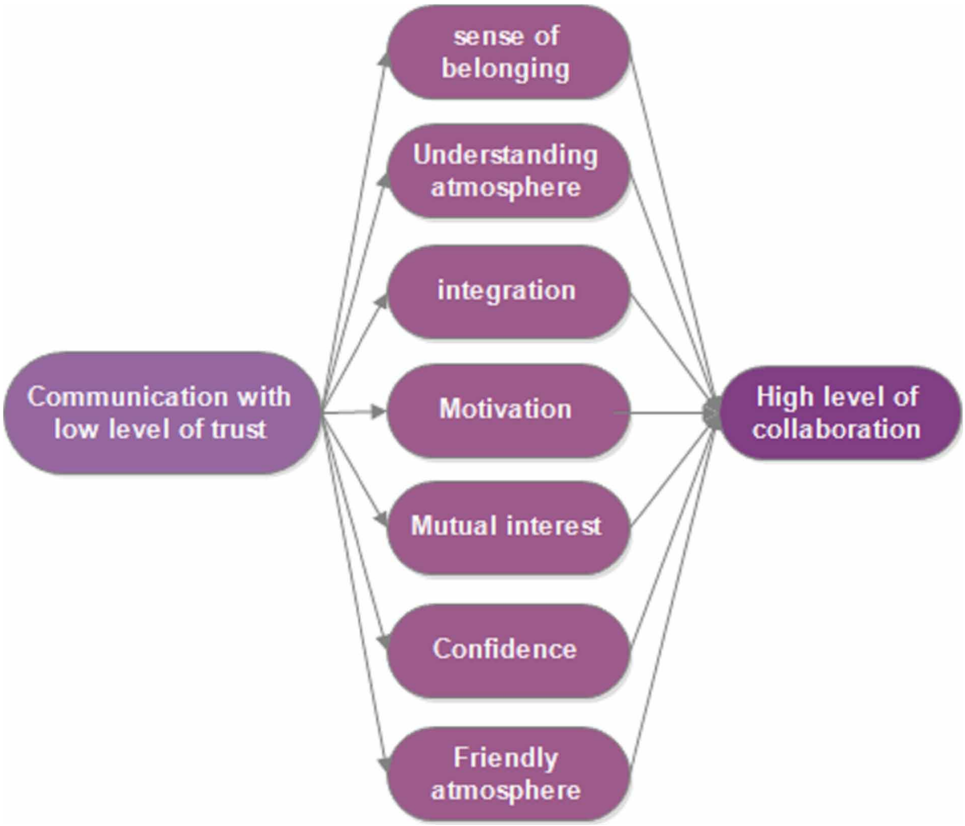


When interpersonal trust is present in the relationship between communication and collaboration, the teammates seem to develop a sense of belonging which is essential to the development of healthy relationships within the team: “Just communication is not enough to get things done while trust bring more of the “belonging feeling” for collaboration” (respondent 1). Moreover, “Trust (in communication) breeds familiarity and allows us to share freely”, as said respondent 3. This sense of belonging motivates the teammates to invest in their work beyond the basic needs of the tasks or project. They find interest in their work. The motivation and the interest in their work will cause them to “work better and faster” because “the requirement comes from a colleague he (they) appreciate at a personal level”, as affirmed respondent 8. When interpersonal trust is joined to communication it allows a team to develop communication at a higher level where communication is not just an exchange of messages. This higher level is an upgrade of communication to a means that enables communication not only for an exchange of messages but also for a deeper understanding and better integration between the members of the virtual team as wrote respondent 2: “trust and respect are important for any type of communication which requires deep understanding and integration between the different parties”. When people understand each another and when there is integration between them, they are ready to share knowledge, ideas and thought and the others are ready accept and trust the input. Thus, respondent 13 argued: “It was therefore essential that each & every team member was encouraged to share their knowledge with the team and that their input was trusted by their fellow team members. Without this high level of trust, our complex business development efforts would simply not have succeeded”. Interpersonal trust as a mediator of communication allows collaboration to lead to a higher performance of the team: “Therefore, when leading a team, considering that the objective is to perform as much as possible, this can only be reached if all members are top performing, which in most cases, requires collaboration between the team members. And the collaboration will only take place if the members trust each other, and if they trust their team leader” (respondent 4). As has been deduced from the answers of the respondents, several items were identified as catalysts for reaching a high level of collaboration with the help of interpersonal trust in the relationship between communication and collaboration (figure 3).

DISCUSSION

The findings of the correlation analyses supported previous studies that discovered the existence of a relationship between these variables. Firstly, communication was found to be highly related to collaboration as an outcome, in agreement with other studies (Mattessich, Murray-Close, & Monsey, 2001; Qureshi, Liu, & Vogel, 2006;

Figure 3. Factors generating high level of collaboration



Hosley, 2010). Secondly, our findings reflected high correlation levels between communication and trust. These findings are consistent with other studies and support previous empirical research (Jarvenpaa & Leidner, 1999; Zeffane, Tipu, & Ryan, 2011; Remidez & Jones, 2012). Thirdly, the study also found that the two types of trust and collaborative processes are highly correlated. These research findings are similar to other studies showing the significant impact that trust has on collaboration in the regular work environment (Martínez-Miranda & Pavón, 2012) as well as in the virtual environment (Peters, 2003; Peters & Manz, 2007). Moreover, cognitive-based trust correlated more prominently on most of the variables than did affective-based trust, especially for knowledge sharing. Furthermore, a large effect-size gap between cognition-based trust and affective-based trust was found on knowledge sharing, and a minor gap was found on problem solving, conflict management, and decision making. The findings showed that knowledge sharing, problem solving, conflict management, and decision making are processes relying more on rational and technical relationships than on emotional and social relationships. Nevertheless, for innovation and creativity process, an inverse association was found.

At the second stage of our study, after finding positive correlations between the variables, we examined the type of relationship between the variables and mediation analyses. The effect's size differences between cognition-based trust and affective-based trust have an influence on the mediation's level between task-oriented communication and collaborative processes. Nonetheless, the two types of trust were found as mediators in three cases (problem solving, conflict management, and decision making). In two other cases, knowledge sharing and innovation and creativity only one type of trust was found as mediator: cognitive-based trust and affective-based trust, respectively.

Related to Hypothesis 1, Cognitive -based trust was found to be partially mediating the relationship between task-oriented communication and knowledge sharing, and affective based trust was not found to be a mediator. Therefore, Hypothesis 1 was partially supported. In the process of knowledge sharing, the team members evaluate the experience, professional knowledge, and skills of their fellow team members. Thus, performance-relevant cognitions, based on logical and rational thinking, were shown to be the most practical way to evaluate the prospects of accomplishing tasks in the team, especially in distributed working environments and distant relationships. These results are in agreement with a previous study that found that teams seeking knowledge sharing must be focused on cognitive-based trust rather than affective-based trust (Chowdhury, 2005).

For problem solving, conflict management and decision making, both cognitive-based trust and affective-based trust were found to be partial mediators. Thus, Hypotheses 2, 3, and 4 were fully supported. The moderate to high effect size values and the minor gap between cognition-based and affective-based trust strengthens the mediation findings. Cognitive-based trust seems to have a better impact than affective-based trust on the relationship, but for achieving a higher level of collaboration, affective-based trust is critical.

Creating task-oriented communication poses a challenge in virtual environments, and trust plays a crucial role in the relationship between task-oriented communication and collaborative process. Because problem solving, conflict management, and decision making are structured processes requiring rational and logical thinking, cognitive-based trust plays an important role as mediator, like knowledge sharing. However, for these three collaborative processes, affective-based trust is also necessary in order to complete the processes. To reduce tension between parties, conflict management requires professional and practical attention to solve the conflict to accomplished task-oriented communication. Hence, along with logical and rational arguments, affective persuasion based on emotional roots are also needed, such as in cases of cultural or language conflict. Problem solving within the team requires suggesting solutions and evaluating them, and choosing best alternative. In brainstorming, not only is structured thinking necessary to resolve a problem, but also open thinking that facilitates multiple and diverse perspectives. To achieve the best solution, teammates need to be able to express themselves openly and communicate freely. Team decision making in organizations necessitate logical and rational judgement to evaluate the alternatives and consequences to reach the best results to accomplish their tasks. Also, structured decisions are frequently being taken in operational and middle level of management in organizations. Furthermore, team decision making requires a high level of consideration of other teammates' opinions and high-reaching of confidence between them.

Regarding Hypothesis 5, while affective-based trust was found as partially mediating the relationship between task-oriented communication and innovation and creativity, cognitive-based trust was not found as a mediator. Therefore, this hypothesis was only partially supported. In innovation and creativity processes, rational thinking is less critical. This is a dynamic process with many detours and feedback loops. It includes 'thinking out of the box' and offering unusual ideas which may require taking risks between the teammates. In addition, this process can bring about qualitative changes, as it often breaks with conventional wisdom and well-established practices. Therefore, it is essential that team members work in "human components" environment, such as one that is sympathetic and supportive, thus allowing teammates to share ideas and to express themselves freely. In this light, the creation of relation in an atmosphere of trust and respect is necessary.

This study strengthens the argument that trust is a mediating factor and therefore has an indirect effect on collaboration (Qureshi, Liu, & Vogel, 2006; Brahm & Kunze, 2012). The findings showed that a high level of task-oriented communication and the two types of trust lead to a higher level of collaboration. They also highlight the fact that the impact of communication's strength on collaboration is mediated by the level of trust existing between team members. Furthermore, some collaboration processes require more cognitive-based trust while others require more affective-based trust, depending on the degree of social skills required for the process and on whether the process is more structured or innovative.

This study enriches previous research in several ways. First, it enhances the knowledge base of virtual teams' collaboration field. Second, unlike in previous research, the study distinguishes between two complementary types of trust: cognitive-based and affective-based. This distinction enables a better understanding of trust as a mediator of task-oriented communication and collaboration. Third, the study also disassembled the collaboration phenomenon into five different, but complementary, processes. These categories allow us to examine and analyze the impact of trust on each process separately. It should be emphasized, that to the best of our knowledge, this is the first time that collaboration among virtual teams was separated into five processes in one study. Fourth, despite the common assumption that only cognitive-based trust plays a central role in task-oriented communication, our findings show that affective-based trust is not only significant in some of the processes, but plays a key role in these processes.

The qualitative analyses allow one to understand the reasons why communication with trust leads to better collaboration. Lack of trust creates a negative atmosphere at work where people have neither interest nor motivation; they fear getting involved and being active. Miscommunication leads to misunderstanding and often causes negative emotional reactions. In these conditions, teammates cannot reach high levels of collaboration. On the contrary, the presence of trust allows team members to feel that they belong to a group not only for work purposes but also on a social basis. It allows them to develop mutual interest and motivation by creating a friendly and understanding atmosphere. This will help the team to achieve better and more effective collaboration.

PRACTICAL IMPLICATIONS

It is clear from this study that organizations striving to have their teams achieve high levels of collaboration need to develop and invest in task-oriented communication skills and trust building. Based on the findings of the mediation model, it can be deduced that if organizations focus only on task-oriented communication skills and neglect to facilitate trust building within their teams, the impact of communication on collaboration will be deficient. Therefore, in light of its centrality, trust must be developed and nurtured by organizations by any available means.

Organizations need to determine the type of trust characteristics that are most essential to develop, pursuant to the types of tasks to be accomplished. The differences between cognitive-based trust and affective-based trust have an impact on communication characteristics and channels to be used by the virtual team. Our research model can help organizations in two ways: first, confronting the collaboration challenges by acquiring a better understanding of the unique aspects of the virtual environment, and second, raising the awareness of trust team building, both cognitive based and affective based, and its role as a mediating factor. Thus, organizations can adopt the optimum communication tools, depending on which collaborative processes they aim to achieve. Thus, the model can help organizations define the appropriate content of the messages according to the established type of trust.

Consequently, to enhance cognitive-based trust, organizations need not only to use common communication tools, such as emails and collaborative writing, but also need to highlight and delineate the responsibilities, competences, and achievements of teammates during task-oriented communication. Likewise, for affective-based trust, using audio and video tools could facilitate the enhancement of social bonds. Along with the visibility enhancement, organizations need to generate intense interaction which emphasizes empathy, affiliation and relationship. It is imperative that organizations ensure that virtual teams are using the right ICT channels according to the two types of trust, and the five collaborative processes (see Kauffmann & Carmi, 2014).

In summary, the results of this study can help organizations better understand the collaborative processes and mechanism of teams working in a virtual environment. The analysis can help organizations identify the attributes of each process in order to classify them on the spectrum of more rational based or more social based. Disassembling collaboration to five complementary processes enables organization to develop more precise management tools, increase team efficiency, team performance, and the quality of their outcomes in order to become more competitive and creative.

LIMITATIONS AND FURTHER RESEARCH

This study has several limitations, and some of the major ones are enumerated in this section. The first limitation concerns the small sample size. On the one hand, the sample has maximum variation, thereby eliciting a wide range of approaches to the items. On the other hand, the conclusions might vary according to the sector (e.g., finance, health, electronics), type of organization (e.g., low-tech or high-tech), the education and culture of the teammates, and other parameters. Therefore, it is suggested that further research expand the parameters or focus more deeply on certain parameters. It is recommended to use the type of virtual team based on time (temporary vs. ongoing) and location (local vs. global) as control variables.

A second limitation relating to the study's framework is the adopted definition of collaboration. The study examined five processes that were identified in the literature as strongly related to collaboration. However, collaboration can also be defined by other processes, such as team learning. Further research could be conducted to analyze additional aspects of collaborative processes.

Thirdly, the analysis method of this study assumed that the relationship between communication, trust, and collaboration is linear, where task-oriented communication is antecedent to the two types of trust and collaborative processes. However, it may be that the relationship between the variables is more complex. Therefore, further research could modify the order of the relationship of the variables, or use qualitative methods to achieve a deeper understanding of the relationship between these variables.

Finally, in this study, all data were collected through web surveys, which raises the issue of common method variance as a possible source of research bias.

SUMMARY

Virtual teams have emerged as a common phenomenon at the workplace. Thus, organizations face the challenge of seeking to maximize the benefits of virtual teams. Some of the advantages include round-the-clock scheduling, flexible and configurable positing staff, and being able to assign the most qualified workers for the team task. Among the challenges to effective collaboration is the lack of unmediated communication

The study model sought to identify antecedents for collaboration in a virtual environment. Findings indicated that a high level of task-oriented communication will lead to a higher level of collaboration and as a result, enhance team effectiveness. The impact of communication on collaboration is mediated by the level of trust established between the team members. The findings showed that trust is a partial mediator in task-oriented communication, with cognitive-based trust somewhat more prominent than affective-based trust. Nevertheless, the development of trust based solely on cognitive factors is insufficient, with affective-based trust remaining an important factor for collaboration enhancement.

In light of this research, it is suggested that managers not only focus on rational trust but will take into consider the social trust. Even when social and emotional trust seems very hard to develop in virtual environment, they still have to find ways to develop social bonds to achieve higher levels of collaboration. Further to that, organizations ought to create and seek any opportunity for social interactions in virtual environment, using any available means of communication. Moreover, in order to achieve maximum effectiveness, organizations must attend to each collaborative process as unique, and find the appropriate balance between cognitive-based trust and affective-based trust in each process.

As noted, it is through communication that collaboration can be established. However, without trust between the virtual team's members, the quality of this collaboration will be low. With the help of trust, cognitive as well as affective, communication can lead to a higher quality of collaboration and a more effective one.

Summing up, in the 21st century competitive business environment, organizations must be dynamic, innovative, able to adapt quickly, and able to find solutions to new situations daily. They need teams to share information and knowledge openly, to solve problems and conflicts efficiently, to make the best decisions, and to be innovative and creative during their assignments. The performance of team collaboration will be defined by the optimal blend of cognitive-based trust and affective-based trust in these five collaborative processes.

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Chapter 10
Framework for Managing Shared Knowledge in an Information Systems Outsourcing Context

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ABSTRACT

Both information systems outsourcing and knowledge management are well-established business phenomena. Regardless of organisational reasons for information systems (IS) outsourcing, knowledge remains the single most important resource for organisations to be managed. In an attempt to provide tactical mechanisms for creating and managing shared knowledge in organisations embarking on IS outsourcing arrangements, this chapter focuses on the design and application of a knowledge framework for IS outsourcing, with the purpose of guiding organisations in their knowledge exchange planning through concrete mechanisms, practical steps, and validation. Key considerations for information systems outsourcing is mapped

DOI: 10.4018/978-1-7998-2355-1.ch010

to critical success factors, each associated with a set of knowledge requirements and knowledge flows to support the successful achievement of a specific critical success factor. An associated assessment tool was designed to identify knowledge exchange mechanisms and potential issues and gaps in current or future information systems outsource arrangements.

INTRODUCTION

Information system (IS) outsourcing is an organisational practice aligned to organisational objectives of transferring all or a part of the organisation's IS functions to an independent third party under the terms of a formalised agreement (Globerman & Vining, 2017; Reyes González, 2016). Through outsourcing, an organisation gains access to expertise, knowledge and capabilities of its outsource partner (Brown & Fersht, 2014).

Knowledge is an essential consideration for IS outsourcing activities and choices from two perspectives. Firstly, organisations share organisational knowledge with the outsource vendor through the outsourcing process and, in turn, acquire external knowledge from the outsource vendor (Mansingh, Osei-Bryson, & Reichgelt, 2009; Tajdini & Nazari, 2012). Secondly, the transfer of knowledge is important for the vendor selection and contract negotiation period, the implementation and service transfer period and all the way through the contract management and contract maintenance period (Mansingh et al., 2009; Zelt, Wulf, Uebernickel, & Brenner, 2013). Since the loss of knowledge may impact both the organisation and outsource vendor negatively, particular and focussed attention is required in order to develop and sustain the creation of new knowledge, as well as sharing existing knowledge (Alexandrova, 2012; Willcocks, Hindle, Feeny, & Lacity, 2004).

Multiple research studies in the past focused on the impact of knowledge-sharing mechanisms on shared knowledge and outsourcing accomplishment (Beyah & Gallivan, 2001; Blumenberg, Wagner, & Beimborn, 2009; Fehrenbacher & Wiener, 2019), while little consideration has been given to theoretical frameworks guiding an understanding of IS outsourcing specifically (Beyah & Gallivan, 2001; Jennex, 2017; Jennex & Adelakun, 2014; McIvor, 2000). One aspect that lacks attention is the management of knowledge-based assets in IS outsourcing. (Currie & Pouloudi, 2000b) argue that the growing practice of IS outsourcing encourages researchers to study the value of knowledge-based assets, as well as the degree to which knowledge-based assets can be obtained or lost through IS outsourcing. Teo (2012) agrees that, while scholars highlight the significance of knowledge management in IS outsourcing, little research has been concluded on how organisations manage knowledge in outsourcing circumstances. A need therefore exists for the establishment of a set of tactical mechanisms that may assist organisations during the IS outsource process to ensure that knowledge is properly managed, captured and available.

The main purpose of the study presented in this paper is to conceptualise such tactical and application mechanisms within a knowledge framework for organisations embarking on IS outsourcing. The aim of the knowledge framework is to assist and guide organisations in their knowledge exchange planning through concrete mechanisms, practical steps and validation. Key considerations for information systems outsourcing is mapped to critical success factors, each of which is associated with a set of knowledge requirements and knowledge flows to support the successful achievement of a specific critical success factor. The research was guided by the research question of 'what are the critical success factors for knowledge exchange in an IS outsourcing context and how can organisations measure these factors with a focus on knowledge requirements and knowledge flows?'.

In the next section the background to the study is presented, followed by an overview of the research methodology employed. Thereafter we present the analysis of the data collected, the proposed framework, and conclude the paper with a discussion of the contribution of the paper.

BACKGROUND

Organisations today face the challenge of creating an infrastructure that facilitates knowledge transfer through defining and quantifying the source and nature of the bodies of knowledge in the organisation (Hislop, Bosua, & Helms, 2019; Muñoz, Mosey, & Binks, 2015). In addition, an organisation must protect itself from knowledge leaving the organisation in order to optimally use what it knows across all perspectives of vision, strategy, roles, skills, policies, procedures, tools and platforms (Clarke & Rollo, 2001; Jennex, 2008; Khan & Vorley, 2017). An understanding of knowledge in organisations, the modes and context of conversion of knowledge and the technologies used in this conversion, are tactical approaches to knowledge creation (Khan & Vorley, 2017; Marwick, 2001; Vequist & Teachout, 2006).

The rest of this section further explores knowledge transfer processes and specifically the transfer of explicit knowledge, the transfer of tacit knowledge and the externalisation of explicit knowledge in order to understand the theoretical grounding for knowledge exchange in IS outsourcing arrangements. This is followed by an introduction to the key consideration for knowledge exchange in IS outsourcing and an introduction to tactical and application mechanisms for IS outsourcing.

Knowledge and IS Outsourcing Phases

Knowledge is an essential element of an IS outsourcing arrangement, as knowledge flows in both directions between organisation and the outsource vendor with the aim of increasing the collective knowledge of each other's knowledge domain (Bandyopadhyay & Pathak, 2007; Blumenberg et al., 2009; Nonaka, Toyama, & Konno, 2000). Frequent interaction through team structures and communication tools, could create a common frame of reference and plays an important role in idea generation and organisation-vendor knowledge assimilation (Balaji & Ahuja, 2005; Blumenberg et al., 2009).

Knowledge-based assets, knowledge sharing and knowledge management pertaining to IS outsourcing, are not a stand-alone practice and should rather be incorporated into all phases of outsourcing (Aydin & Bakker, 2008; Balaji & Ahuja, 2005; Blumenberg et al., 2009). Furthermore, leveraging already-accumulated knowledge is by far the lowest-cost way available to harness innovation (Koriat & Gelbard, 2018; Krogh, Ichijo, & Nonaka, 2000; Nonaka & Takeuchi, 1995). Knowledge assets, namely know-how and experience, must be channeled and made available (Frappaolo, 2006; Smuts, Kotzé, Van Der Merwe, & Loock, 2015b). Knowledge management in this instance not only includes the management of knowledge assets, but also the management of the processes that act upon the knowledge assets, such as developing knowledge, preserving knowledge, using knowledge and sharing knowledge (Mentzas, Apostolou, Abecker, & Yoing, 2003; Vishwakarma, Tripathy, & Kothari, 2018). This involves the identification and analysis of available and required knowledge, and the subsequent planning and control of actions to develop knowledge assets in support of the outsourcing phases (Vishwakarma et al., 2018).

(Cullen & Willcocks, 2003) acknowledged three distinctive phases of outsourcing: (1) the architect phase, (2) the engage phase and (3) the govern phase. The *architect* phase focusses on the outsource scoping, the business case and the design of the outsource requirement, while the *engage* phase deals with the outsource vendor procurement. The *govern* phase comprises of the outsource contract management and agreement deliverables (Alborz, Seddon, & Scheepers, 2003; Chandar & Zeleznikow, 2014; Cullen & Willcocks, 2003).

Business value delivery for the organisation by means of these three phases of IS outsourcing is in essence a set of knowledge-based activities, as it encompasses the "integration and harmonisation of knowledge from many individuals of different disciplines and backgrounds, with varied experiences and expectations, located in different parts of the organisation" (Blumenberg et al., 2009: 344). Knowledge-transfer processes are therefore important for the establishment of shared knowledge (Blumenberg et al., 2009).

Explicit Knowledge Transfer in IS Outsourcing

Explicit knowledge refers to knowledge that has been articulated, codified, and stored, making it communicable in formal and systematic language (Clarke & Rollo, 2001; Nickols, 2001; Nonaka, Toyama, & Byosiere, 2001).

According to (Blumenberg et al., 2009), explicit knowledge factors in IS outsourcing apply to the assimilation and interpretation of knowledge between the IS outsource vendor and an organisation, such as the extent to which management practices formalise and systemise organisational processes. The identification and utilisation of industry standards and reference models support the creation of a common language between the organisation and the outsource vendor. The continuous improvement process formalises the contractual and service level agreement relationship. Communication must be aligned to different levels of management and explicit interaction structures between the organisation and outsource vendor.

Tacit Knowledge Transfer in IS Outsourcing

Tacit knowledge that relates to human emotions, insights, intuition and acquired through experience and observations, is less tangible than explicit knowledge and more difficult to share (Alavi & Leidner, 2001; Jones, Chonko, & Roberts, 2003). However, the articulation of tacit mental models is an important component of creating new knowledge and suggests that face-to-face engagement is essential for tacit knowledge transfer (Nonaka & Takeuchi, 1995).

(Blumenberg et al., 2009) identified key factors for organisation and outsource vendor tacit knowledge transfer, such as the creation of a joint workforce with the objective to work in close collaboration and exchange information and advice. Trust, as an essential aspect of transfer of tacit knowledge, is fostered through regular close collaboration, robust involvement of both parties, mixed workgroups without functional segregation and through a strong personal bond and collective understanding (Benamati & Rajkumar, 2002; Beyah & Gallivan, 2001; Nguyen, Babar, & Verner, 2006; Sabherwal, 1999). Other contributors to a relationship of trust includes cultural understanding, communication, outsource vendor capability and delivery quality (Nguyen et al., 2006; Varajão, Cruz-Cunha, Fraga, & Amaral, 2012).

The integration of shared knowledge denotes the blending of organisational skills, know-how and expertise with external knowledge sources, and is considered an important precursor to the successful development of an IS outsourcing arrangement (Balaji & Ahuja, 2005; Yam & Tang, 2013). Therefore, knowledge sharing and knowledge transfer processes, must be incorporated into organisational processes and procedures when designing an operative IS outsourcing arrangement (Aydin & Bakker, 2008; Blumenberg et al., 2009).

Learning and Explicit Knowledge Externalisation

Organisational learning processes in IS outsourcing arrangements, comprise of two elements: (1) internalisation of the essential knowledge for the collation and management of the IS outsourcing arrangement, and (2) learning by doing, which refers to the acquisition of the vendor organisation know-how, skills and competencies, with the aim to improve the client organisation's own competitive advantage and strategy (C Boerner, Macher, & Teece, 2003b; Escriba-Esteve & Urra-Urbieta, 2002; Yakhlef, 2009).

The process of externalisation of explicit knowledge starts with individual knowledge acquired by means of experiences and a cognitive learning process. Knowledge conversion takes place between tacit and explicit knowledge and through integration processes. This individual knowledge is then interpreted at an organisational level (King & Zeithaml, 2003; Savino, Messeni Petruzzelli, & Albino, 2017). At the organisational level, knowledge is enriched and amplified by means of interactions among individuals and with the organisation. These individuals involved in the knowledge creation activities, in turn, process this information and transform it into knowledge interpreted by their mental models, and thereby create a mutual understanding through experiences (Blumenberg et al., 2009; Nonaka & Takeuchi, 1995; Yusof, Zakaria, & Zainol, 2016).

Therefore, the application of an IS outsource arrangement, as a means of learning, must be overseen by including the learning processes in the outsource contract. As such, learning processes play a key role in the development and transfer of knowledge among the partners. Within this context of different organisation-outsource vendor knowledge transfer processes, the organisation should understand how to manage the knowledge interaction with an outsource vendor (Mariano & Walter, 2015).

Key Considerations for Knowledge Exchange in IS Outsourcing

With the intention of realising short-range gains and longer-range goals from IS outsourcing, organisations should consider the business risk related to inadequate design, implementation and management of IS outsourcing contracts (Ali & Khan, 2014). In this context, the key factors that organisations should focus on to be successful, must be identified and managed as it focuses the organisation to build their capability towards meeting the critical success factors (Aalders, 2001). In earlier work (Smuts, Kotze, van der Merwe, & Loock, 2015a) these key considerations were identified and associated with the IS outsourcing phases (Cullen & Willcocks, 2003).

Key considerations for the *architect* phase of IS outsourcing point to organisational activities required to determine the scope of the outsourcing, such as obtaining market intelligence and insight, the business case and objectives for outsourcing, the benefits analysis and benefits expectations, as well as the budget and cost analysis. The outsourcing model and outputs are also key considerations in the architect phase and include the decision around the outsourcing approach, the target service definition and the outsource arrangement model. Some key considerations are internally focused within the organisation, such as the structure of the outsource arrangement, the organisational team structure of the retained organisation, organisation buy-in into outsourcing objectives, realistic expectation management, as well as the clear definition of service parameters and the business case for outsourcing (Smuts et al., 2015a).

Key considerations for the *engage* phase of IS outsourcing include elements that relate to the organisational and contract design, due diligence, risk assessment and outsource vendor screening. The communication strategy, staffing arrangements and the contract management organisation were identified as key factors, while the implementation and transition plan, the measurement dashboard of outsource expectations and the definition of the quality measures were also highlighted (Smuts et al., 2015a).

Key considerations for the *govern* phase of IS outsourcing focus on all elements of the management of the outsourcing contract, such as outsourcing arrangement execution, the relationship management, the resource planning, the behavioural change management, the defect management and tracking and the programme planning and execution (Smuts et al., 2015a).

Tactical and Application Mechanisms for IS Outsourcing

In the context of IS outsourcing, knowledge is transferred beyond organisational boundaries and knowledge from different organisations interacts to create new knowledge (Nonaka et al., 2000). In order to deliver value to the organisation, the IS outsourcing arrangement must be embedded with trust and confidence, focussed on clear goals and regular performance monitoring aligned to the key considerations for outsourcing in the first place (Blumenberg et al., 2009; Oza, Hall, Rainer, & Grey, 2004; Sabherwal, 1999; Vorontsovaa & Rusub, 2014).

Mere identification of the key considerations for IS outsourcing (Smuts et al., 2015a), without providing guidance on how to address the considerations, is, however, of limited value to organisations considering IS outsourcing, or looking for guidance on how to manage such an arrangement. In order to assist organisations in considering and managing these key considerations within the three phases of IS outsourcing, the argument in this paper is that the necessary tactical and application mechanisms needs to be associated with the key considerations.

The objectives or key considerations of IS outsourcing often inform critical success factors as they usually state what the requirements are for delivering the objectives (Aalders, 2001; Beaumont & Sohal, 2004). Critical success factors refer to key characteristics an organisation must manage in order to achieve their outsourcing objectives and are best raised initially as statements of concern (Aubert, Patry, & Rivard, 2005; Lam & Chua, 2009; Rhodes, Lok, Loh, & Cheng, 2016). In order to monitor performance and manage knowledge leakage risk, critical success factors would provide the essential areas of activity that must be performed well in order to achieve the goals of the IS outsource arrangement.

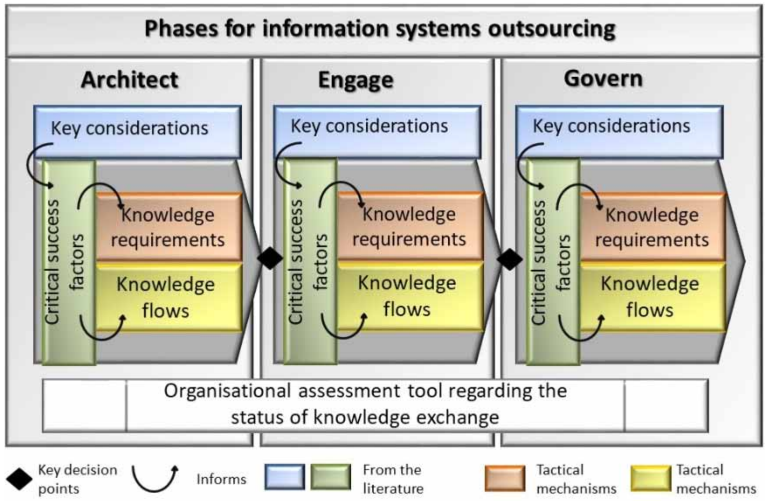
Furthermore, a shared knowledge base is foundational for coordination between the client organisation and outsource vendor and knowledge-transfer processes are therefore important for the establishment of such a base (Blumenberg et al., 2009; Nonaka et al., 2000). Knowledge transferred among partners are classified into different levels of inherent composition and scope of organisational application in the context of outsourcing arrangements (Yakhlef, 2009). Knowledge creation, sharing among various communities and groups of users require coordinative management and exchange of knowledge. These knowledge requirements utilises different channels for flow of the knowledge, as well as a means for processing and conversion of knowledge from one form to another (Milovanović, 2011).

Also, as alluded to in the introduction, multiple research studies in the past focused on the impact of knowledge-sharing mechanisms on shared knowledge and outsourcing accomplishment, little consideration has been given to theoretical frameworks guiding an understanding of IS outsourcing specifically, or on how organisations manage knowledge in outsourcing circumstances (Beyah & Gallivan, 2001; Blumenberg et al., 2009; McIvor, 2000; Teo, 2012). A need therefore exists for the establishment of a set of tactical mechanisms that may assist organisations during the IS outsource process to ensure that knowledge is properly managed, captured and available.

To address this problem and the specific need for guidance on how to address the key considerations for IS outsourcing (Smuts et al., 2015a), a knowledge framework for IS outsourcing is proposed in this paper. The proposed framework and the relationship between its various components are illustrated in Figure 1.

The proposed knowledge framework maps the identified key considerations for IS outsourcing (Smuts et al., 2015a) to critical success factors for IS outsourcing. Also in order to understand what knowledge exchange will ensure successful achievement of the identified critical success factors, it is proposed that knowledge requirements

Figure 1. Knowledge framework for IS outsourcing



and knowledge flows in the context of an IS outsourcing arrangement, and related to the particular critical success factor, should be considered.

In order to ensure practical application of all the tactical mechanisms, the development of an assessment tool that organisations may use to identify knowledge exchange mechanisms when embarking on IS outsourcing, or to identify potential gaps in an existing IS outsource arrangement, is proposed.

The next section describes the research methodology followed to develop the proposed knowledge framework for IS outsourcing.

METHODOLOGY

The research methodology used in the development of the proposed knowledge framework for IS outsourcing is interpretive in nature making use of both primary and secondary data resources. A variety of qualitative data collection methods, including literature reviews, content analysis, interviews and questionnaires were utilised.

Determining Critical Success Factors for IS Outsourcing

Whilst the key considerations in the data model indicate the significant factors that are required and which guide the IS outsourcing arrangement during the design phase of IS outsourcing, critical success factors are the leading factors for the design phase of IS outsourcing. Criteria for selecting the outsource vendor is also be obtained from the critical success factors, as related evidence that the outsource vendor can deliver the deliver the required services (Aalders, 2001; Beaumont & Sohal, 2004; Laplante, Costello, Singh, Bindiganavile, & Landon, 2004; Sparrow, 2003).

Each critical success factor must be proven to be necessary and a collection of critical success factors must be present in order to be sufficient for success (Aalders, 2001). In order to determine the critical success factors for IS outsourcing, a literature review was concluded.

The key considerations and critical success factors obtained informed the next step, which was to collect data on tactical mechanisms describing the knowledge required and the knowledge flows relevant in client organisation and IS outsource vendor knowledge exchange.

Determining Knowledge Requirements and Knowledge Flows

Each critical success factor is related to the knowledge requirements and knowledge flows contributing to the particular factor. Knowledge requirements points to the specific knowledge required to achieve a critical success factor and knowledge flows highlights the mechanisms for sharing the knowledge requirements.

To determine knowledge requirements and knowledge flows, questionnaires, as primary data collection method, was used to collect data in one of the largest telecommunication organisations in South Africa. The organisation adopted a multi-sourcing philosophy and as work is outsourced to multiple vendors, a significant number of large outsourcing programmes are active at any point in time.

The project leader for the study described in this paper was assigned to such IS outsourcing programmes. This involvement supplemented the research and data collection by providing insights into processes and information, which would be difficult to obtain as an outsider.

Since the identification of a sample in the entire population of interest for primary data collection is related to the research question that must be answered for a particular study (P. D. Leedy & Ormrod, 2014b), purposive sampling was the preferred sampling method. Purposive sampling is the process through which the researcher chose units based on their purpose (Layder, 2013; P. D. Leedy & Ormrod, 2014b). As the research study aimed to conceptualise the elements of a knowledge framework for creating and managing shared knowledge in organisations embarking on IS outsourcing, the rationale and criteria for the selection of potential research participants were based on their area of expertise and the type of work they performed in IS outsourcing projects at the South African telecommunication organisation. The type of work included:

- Involvement in IS outsourcing programme work streams, namely business requirements (e.g. business analysts, business architects, application owners, business owners), technical requirements (e.g. system analysts, solution architects, developers, testers), programme management (e.g. project managers, behavioural change managers, trainers) and commercial management (e.g. procurement, commercial legal).
- Resources allocated to the IS outsourcing programme resources where knowledge and knowledge sharing are key focus areas, where they possess systems and business process management knowledge, as well as knowledge and expertise about outsource vendor management.
- Representation from different management levels from both the client- and outsource vendor organisation, including onsite, near-shore and offshore resources.

To collect data regarding tactical knowledge requirements and knowledge flows in an IS outsourcing arrangement, research participants were selected from a project where the requirements definition had to be delivered for the replacement of a legacy retail billing and customer management system. A systems integrator was selected as outsource partner, by means of a procurement process, with the assignment to deliver a high level solution design and architecture, a business process model for the entire solution, a detailed project plan for the implementation of the solution and a data migration strategy. From an organisational perspective, the objective was to acquire the design for a future-proof, integrated and optimised business process set. Since the focus was strategic in nature, the client organisation assigned senior, specialist, permanent employees, as well as specialist external consultants to the IS outsourcing programme. As the IS outsourcing programme team consisted of the outsource vendor (system integrator) resources, permanent employees and specialist consultants resources, the requirement for knowledge sharing among the team members was amplified.

The target audience identified for the data collection for the knowledge requirements consisted of senior and executive managers within the IS outsourcing programme team – both client organisation and outsource vendor roles. A web link to the online questionnaire was distributed via email to 78 people upon the close-out of the large IS outsourcing project. Thirty responses were obtained, constituting a response rate of 38% of which 66% represented outsource vendors and 34% the client organisation. The profile of research participants are depicted in Table 1.

Table 1. Participant profile for knowledge requirements

Profile Type	Invited	Participated	Management	Team member
Client organisation	34	10	5	5
Outsource vendor 1	21	13	4	9
Outsource vendor 2	2	0	0	0
Outsource vendor 3	7	2	0	2
Outsource vendor 4	8	4	0	4
Outsource vendor 5	2	1	0	1
Outsource vendor 6	4	0	0	0
TOTAL	78	30	9	21

The knowledge requirements questionnaire included questions to:

- Establish what the source of knowledge is, i.e. from a knowledge base (explicit), or held by an individual working on the IS outsourcing arrangement (implicit).
- Establish what specific knowledge requirements are referenced to execute the three phases of IS outsourcing.
- Establish the process by which the required knowledge is obtained, for example learning by doing, training, direct observation and narration, imitation, experimentation and comparison, joint execution, documented knowledge repository or lecture.
- Understand the knowledge and expertise in the context of knowledge held within the organisation versus obtain the knowledge from the outsource vendor.
- Identify whether different knowledge requirements and knowledge sharing processes exist for the three phases of IS outsourcing.
- Provide any general feedback and comments regarding the knowledge requirements of the IS outsourcing arrangement.

The target audience for the questionnaire related to the knowledge flow data collection cycle consisted of the programme team that was assigned to the outsourced implementation of the replacement of a legacy retail billing and customer management system. This included permanent employees from the client organisation, outsource vendor employees, specialist consultant employees and sub-contractor resources. The online questionnaire was distributed via a web-link and emailed to 62 participants, of which 42 completed the questionnaire, representing a response rate of 67%. As indicated in Table 2, of the 42 participants that completed the questionnaire, 22

Table 2. Participant profile for knowledge flows

Profile Organisation Type	Responses	Profile Role Type	Responses
Client organisation, permanent employee	22	Technical team (e.g. IS, Network)	9
Client organisation, contractor or consultant	12	Programme team (e.g. Programme and project managers)	10
Outsource vendor organisation	8	Business requirements and analysis (e.g. Business analysts)	23
Total	42	Total	42

were permanent employees of the client organisation, 12 were specialist consultants contracted to the client organisation and eight were employed by the outsource vendor. With regards to the roles they perform in the business, nine were from a technical team, ten from a programme team, and 23 were related to business requirements and analysis. Table 2 shows the profile of the research participants that provided input on knowledge flows.

The knowledge flow questionnaire included questions to:

- Determine the respondent's contribution to outsourced work stream and the respondent's contribution to the outsource phases.
- Determine the knowledge management system used in order to obtain information for the outsourcing arrangement, and the primary reasons for using the particular knowledge management system.
- Determine the way in which the knowledge requirements flow in the outsourcing arrangement.
- Determine what knowledge flows would facilitate better knowledge transfer in the architect, engage and govern phases of IS outsourcing.
- Provide any general comments on knowledge flows for IS outsourcing.

The responses obtained from the questionnaires for knowledge requirements and knowledge flows were tallied, the trends were analysed and the output reported on. The open-ended questions in the questionnaires were analysed by using a combination of open coding and axial coding (Boeije, 2010; P. Leedy & Ormrod, 2014a). Open coding was facilitated by assigning transcription codes to the data analysed and axial coding was then applied in order to create themes.

Designing the Assessment Tool

Using content analysis, relationships between knowledge flows and knowledge requirements and between knowledge requirements and critical success factors were created. These relationships were utilised to design an assessment tool that organisations may use to identify knowledge exchange mechanisms when embarking on IS outsourcing, or to identify potential gaps when engaging in an IS outsource arrangement already.

The assessment tool consists of a set of questions with data captured through an MS Excel spreadsheet. The outcome of the assessment is presented in an MS Word document, encapsulating an assessment graph summarising the outcome of the assessment.

Validation of the Knowledge Framework

The last step in the methodology was to validate the knowledge framework results, its application and the assessment tool in an organisational context.

Once the framework for knowledge exchange in an IS outsourcing context was designed based on the data collected, three evaluators (not part of the data collections participants) were identified to contribute to the validation of the outcomes of the study based on their expertise in knowledge management and IS outsourcing. The first evaluator was a programme director managing major IS outsource programmes nationally in South Africa, as well as globally. The second evaluator was from the mining industry, an industry other than telecommunication, and the third evaluator represented a global management consulting organisation, offering an outsourcing value proposition from both a management consulting support and an outsource vendor perspective. These three evaluators were selected as they dealt with all the phases of IS outsourcing, at different levels of detail, representing an end-to-end view of outsourcing arrangements.

RESULTS AND VALIDATION

The process by which organisations creates knowledge is of central importance and concerns the manner in which organisations acquire and put into practice, new process and product technologies. Organisational learning is linked to different sources of knowledge internal and external to the organisation (Christopher Boerner, Macher, & Teece, 2003a; Edersheim, 2007; Senge, 1990). The purpose of the knowledge transfer process in an IS outsourcing arrangement is to increase the knowledge that is shared between the organisation and the outsource vendor.

The *key considerations* of IS outsourcing (Smuts et al., 2015a) indicate the significant factors that are required and would guide the IS outsourcing arrangement during the design phase of IS outsourcing. *Critical success factors* are the leading factors for the design phase of IS outsourcing and each critical success factor is related to the knowledge requirements and knowledge flows contributing to the particular factor. *Knowledge requirements* points to the specific knowledge required achieving the critical success factor, and *knowledge flows* highlights the mechanisms for sharing the knowledge requirements. Successful achievement of the identified critical success factors, therefore requires insight into the knowledge requirements and knowledge flows in the context of an IS outsourcing arrangement associated with each success factor.

The proposed knowledge framework for IS outsourcing, as illustrated in Figure 1, combines these various aspects into an integrated whole. In the remainder of this section each of the components of the framework is discussed in more detail.

Critical Success Factors for IS Outsourcing

The organisation and the selected outsource vendor should jointly share accountability, and be committed to achieving shared objectives (Vorontsovaa & Rusub, 2014). In order to deliver value to the organisation, the IS outsourcing arrangement must be embedded with trust and confidence, focussed on clear goals and regular performance monitoring (Blumenberg et al., 2009; Oza et al., 2004; Sabherwal, 1999).

Critical success factors refer to key characteristics an organisation must manage in order to achieve their outsourcing objectives and are best raised initially as statements of concern (Aubert et al., 2005; Lam & Chua, 2009; Laplante et al., 2004; Sparrow, 2003). The objectives of IS outsourcing often inform critical success factors as they usually state what the requirements are for delivering the objectives (Aalders, 2001; Beaumont & Sohal, 2004). Criteria for selecting the outsource vendor must be obtained from the critical success factors as related evidence that the outsource vendor can deliver the required services (Aalders, 2001; Beaumont & Sohal, 2004; Laplante et al., 2004; Sparrow, 2003). Each critical success factor must be proven to be necessary and a collection of critical success factors must be present in order to be sufficient for success (Aalders, 2001).

Guided by the key considerations to outsource (Smuts et al., 2015a), a literature review was conducted to determine the critical success factors for each of the three IS outsourcing phases.

Table 3 (see Appendix) presents the resulting critical success factors for the *architect* phase of IS outsourcing. For the *architect* phase of IS outsourcing, the importance of an integrated IS outsourcing and business strategy, the management of realistic expectations, quantified business benefits, well defined parameters for service quality benefits, and access to client organisation key documentation were highlighted. Another factor that was mentioned was the importance of building skills to manage outsourcing in the client organisation.

Table 4 (see Appendix) presents the resulting critical success factors for the *engage* phase of IS outsourcing. For the *engage* phase of IS outsourcing, an agile procurement process in order to screen and select outsource vendors were mentioned. In addition, the design of the service level agreement and a clear role and responsibility definition were highlighted, as well as the existence of an up to date organisational and business process knowledge repository.

Table 5 (see Appendix) presents the resulting critical success factors for the govern phase of IS outsourcing. Critical success factors for the *govern* phase of IS outsourcing included the delivery performance management, artefact management, contract management, cost management and the application of the service level agreement. From a programme perspective, service integration across outsourcing arrangement work streams, a formal change control process, communication and leadership, and the dry-run of the business integration plan were highlighted.

Knowledge Requirements and Knowledge Flows

Knowledge requirements points to the specific knowledge required achieve the critical success factor and knowledge flows highlights the mechanisms for sharing the knowledge requirements. Knowledge flows emphasise the purpose of creating a shared knowledge base between the client organisation and outsource vendor through pertinent knowledge transfer processes (Bandyopadhyay & Pathak, 2007; Blumenberg et al., 2009).

Guided by the key considerations and critical success factors identified, questionnaires were used to gather data to determine the knowledge requirements and knowledge flows pertinent to IS outsourcing. Using content analysis the data collected was analysed per outsource phase, and the relationships between the knowledge requirements and the knowledge flows were identified.

Table 6 (see Appendix) presents the identified tactical mechanisms for knowledge requirements and knowledge flows for the *architect* phase of IS outsourcing.

Knowledge requirements highlighted for the *architect* phase of outsourcing include market knowledge, knowledge of the client organisation environment and strategic objectives, knowledge of client organisational structures in order to engage with the correct people from the client organisation and outsource vendor, and knowledge of the operations, in order to derive operational type benefits, as key factors. Knowledge of the various cost factors must be considered in terms of development/deployment costs and ongoing costs with a specific emphasis on license costs, human resource costs, hardware infrastructure costs, etc. and knowledge of risk related to the chosen outsource model was mentioned. As an example, an offshore model may imply offshore data which may be a key concern together with the risk of loss of intellectual property.

The identified knowledge flows for the *architect* phase of IS outsourcing point to knowledge transfer as a key objective in the business case, with specific reference to post implementation adoption, support and maintenance of the solution. A skills comparison must be conducted to the internal skills database before considering external skills from outsource vendor and it must be ensured that external skills from the outsource vendor directly address gaps, be complementary to and work alongside existing (similar or developing) skill sets. A business decision making process in support of outsourcing as a business strategy must be established and the work contribution of the outsourcing arrangement must be planned with appropriate stakeholders. In addition, facilitation of more interaction between business, IS, outsource vendors and finance was identified in order to close/minimise a potential disconnect and knowledge gap, as well as presentation of live demonstrations must be considered as a mechanism for the client organisation to learn.

Table 7 (see Appendix) presents the identified tactical mechanisms for knowledge requirements and knowledge flows for the *engage phase* of IS outsourcing.

Knowledge requirements for the *engage* phase of IS outsourcing concern knowledge of service level agreements, outsourcing processes and governance, objectives and mutual benefits of the parties involved, areas that are core and that need innovation and outsource vendor knowledge and their ability to evolve and offer better services. Negotiation skills and knowledge of the negotiation position, as well as knowledge of the support constructs, including legislation, for outsourcing that is required from the client organisation perspective.

Knowledge flows for the *engage* phase of IS outsourcing, include the transparent and easy access to client organisation data, access to a knowledge base of client organisation information, access to the solution benchmarking repository and the availability of a knowledge base of lessons learnt on similar activities. Knowledge sharing sessions with current customers of the outsource vendors on the shortlist must be conducted and a knowledge repository of preferred vendor information must be maintained. The key objective of knowledge transfer must be unpacked into measurable services and products to be included in the criteria for vendor selection and contract negotiation and transparent knowledge transfer channels, where the client organisation stakeholders are kept up to date on the processes used and rationale for vendor selection and subsequent contract terms, must be utilised.

Table 8 (see Appendix) presents the identified tactical mechanisms for knowledge requirements and knowledge flows for the *govern* phase of IS outsourcing.

Knowledge requirements for the *govern* phase for of IS outsourcing include contract management skills and knowledge related to financial and cost management, programme management, critical metrics in relation to the operational environment to measure performance and outsource operational management. The maintenance of the knowledge repository for organisational key knowledge i.e. business requirements and solution design, as well as the key drivers and process for joint execution, were also highlighted.

Knowledge flows for the *govern* phase, elude to formal knowledge transfer workshops between client organisation and outsource vendor in order for the outsource vendor to understand client organisation internal policies and procedures e.g. procurement, purchase order, recruitment etc., benchmarking repository, performance detail. Furthermore, it included the consideration of the impact of scope on data integrity, data migration and data readiness in the new solution towards enabling business benefits. The client organisation must ensure clear communication of expectations and timelines for service delivery, must create a common understanding of status between client organisation and outsource partner that could be represented graphically through status dashboards, checklists, etc. and plan for sufficient and formal hand over time from the outsource vendor to the client organisation.

Assessment Tool

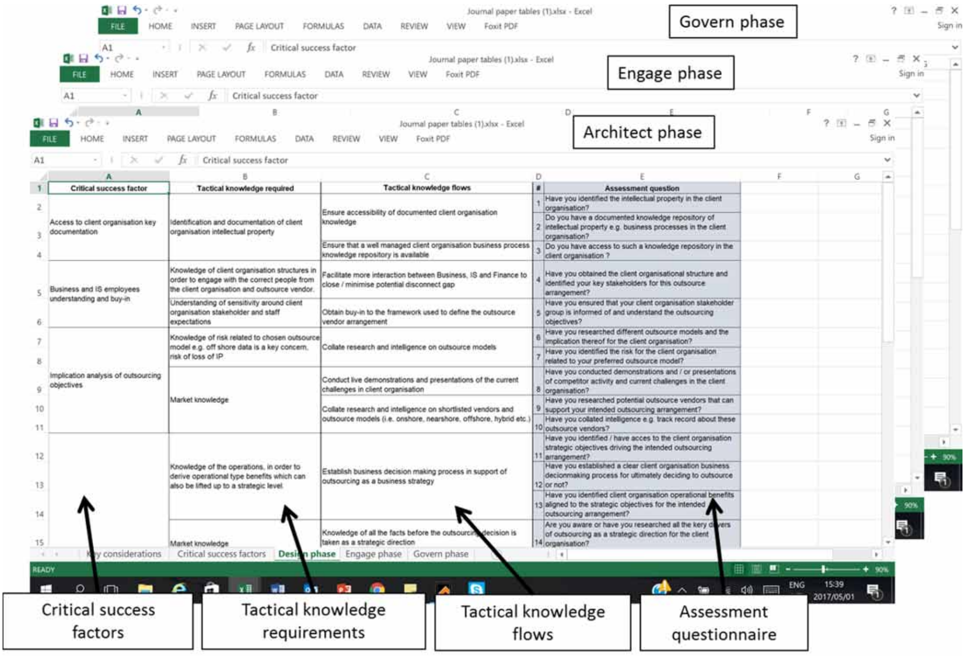
A further objective of the research was to design an assessment tool for organisations embarking on, or busy with an IS outsource arrangement, using the information obtained from the literature review and the data collected through the questionnaires. The aim was to compile the tactical mechanisms as an organisational artefact in support of identifying practical steps towards managing knowledge exchange in an IS outsourcing arrangement.

The purpose of the assessment tool is to:

- Enable organisations to complete a self-assessment questionnaire on the status of knowledge exchange in there is outsourcing arrangement.
- Produce an assessment report that provides the organisation with an assessment result based on the self-assessment questionnaire.
- Illustrate the gap between the organisational assessment and the ideal profile for knowledge exchange.
- Make recommendations to the organisation on what tactical knowledge requirements and flows should be considered to close the gap between the organisational assessment and the ideal profile.

Knowledge flows contribute to knowledge requirements, which ensure that critical success factors are achieved and that risk of failure is mitigated. The first step of developing the assessment tool was therefore to create relationships between

Figure 2. Tactical knowledge exchange with IS outsource partners assessment tool



knowledge flows and knowledge requirements and between knowledge requirements and critical success factors,

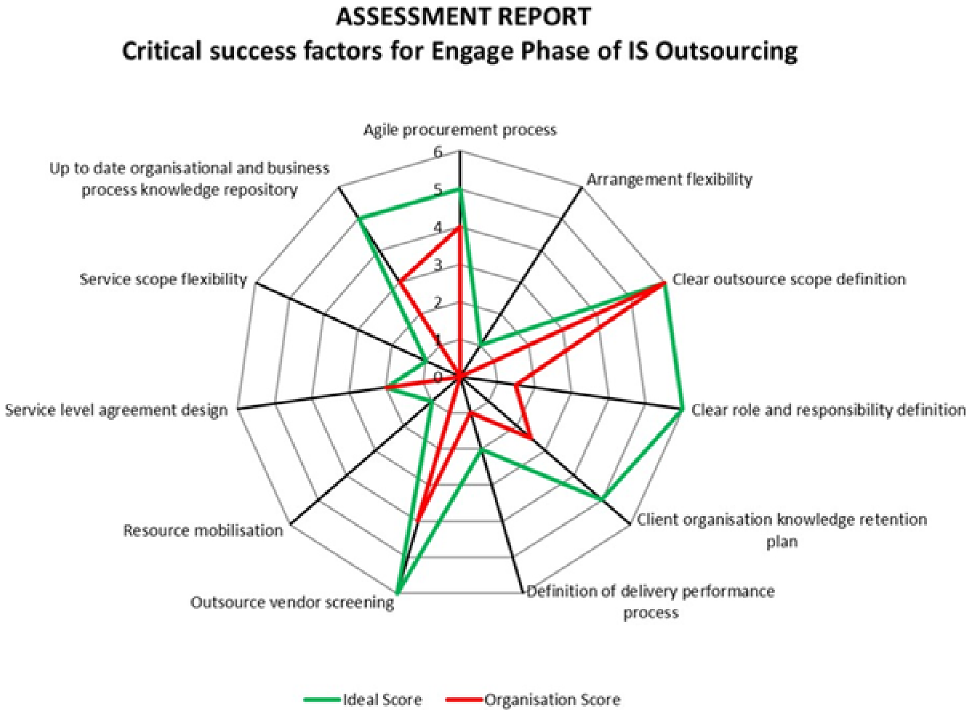
The second step consisted of designing the questionnaire. The knowledge flow level was used to design the questions. Each question was related to a specific knowledge flow data element and specific critical success factor, per IS outsource phase, as illustrated in *Figure 2*. An MS Excel spreadsheet was designed to capture all the inputs to the assessment.

For the *architect* phase of IS outsourcing, 30 questions were defined, 40 questions for the *engage* phase and 48 questions for the *govern* phase of IS outsourcing.

The answers collected for each of the questions were captured in the MS Excel spreadsheet. The questionnaire uses the following rating scale for the answers, each associated with a coded weight value (shown in brackets):

- Organisation response ‘N’ = No (coded with a value of 0 on the Excel spreadsheet and included in the assessment report).
- Organisation response ‘Y’ = Yes (coded with a value of 1 on the Excel spreadsheet and excluded in the assessment report).
- Organisation response ‘S’ = To some extent (coded with a value of 0.5 on the Excel spreadsheet and included in the assessment report).

Figure 3. Example of an assessment graph



- Organisation response 'N/A' = Not applicable (coded with a null value on the Excel spreadsheet and excluded from report).

It is assumed that the ideal score would be a value of '1' for each of the questions. In addition it is assumed that all questions contribute an equal share to the ideal score, and therefore different weights have not been assigned to the different questions (the assignment of a weight is an optimisation that may be applied to the assessment tool as future research).

As an organisational representative completes the assessment, a total score is generated for each critical success factor and entered next to the pre-populated ideal score. An assessment graph is drawn with reference to these two sets of scores and shows the gap between the two. The gap guides the areas of improvement for tactical knowledge exchange in the organisations and is depicted by the difference between the two lines. Figure 3 is an example of what such an assessment graph would look like.

The assessment graph produced is supplemented with an MS Word document dealing with the results for each IS outsourcing phase. The report focuses on the gap between the ideal profile and the assessed values. Knowledge requirements and knowledge flows are reported for each critical success factor, as guidelines on the knowledge elements that should be attended to in order to address the critical success factor and close the gap.

Validation of Knowledge Framework

Three evaluators, other than the data collections participants, were identified to validate the proposed knowledge framework. The first evaluator was a programme director managing major IS outsource programmes nationally in South Africa, as well as globally. The second evaluator was from the mining industry, an industry other than telecommunication, and the third evaluator represented a global management consulting organisation, offering an outsourcing value proposition from both a management consulting support and an outsource vendor perspective. These three evaluators were selected as they dealt with all the phases of IS outsourcing at different levels of detail representing an end-to-end view of outsourcing arrangements.

The first evaluator, an experienced programme director, overseeing large-scale IS outsourcing programmes for global companies, utilised the assessment tool and completed the questionnaire, evaluating one of his organisation's programmes. He shared comprehensive comments on the individual questions in the questionnaire, the completeness of questions in each outsourcing phase, the ease of use of the questionnaire and the relevance of the assessment report.

The next step in validation process was to establish whether the knowledge framework could be applied to outsourcing arrangements other than the IS sector. A participant from the mining sector was selected based on the participant's individual knowledge, technical expertise and experience in the outsourcing field.

Following the completion of the knowledge framework questionnaire by the mining executive, the assessment report was shared with the executive for reflection, validation and feedback. The executive shared his observations from two viewpoints. Firstly, he provided feedback on the ease of use and his experience concluding the knowledge framework assessment and secondly, he provided a comparative validation of the assessment report outcome and his real-life experience with their outsource programmes. He confirmed that the outcome reflected in the assessment report seemed realistic and aligned to his perception of the actual status of their outsourcing project. He highlighted that knowledge framework amplified outsourcing knowledge gaps in his organisation and that he would, by using the tactical knowledge framework suggestions, facilitate a more formal approach to outsourcing. He concluded with confirmation that in his opinion, the knowledge framework may be applied to outsourcing arrangements other than IS and to industries other than telecommunication.

The final step in validation process was to establish whether the knowledge framework could be applied to outsourcing arrangements across industries other than IS industry. A participant from a global management consulting organisation specialising in IS outsourcing as a value proposition was selected.

The senior manager at the global management consulting organisation was interviewed after his assessment of the knowledge framework artefacts. In the interview, he emphasised his opinion that the knowledge framework fulfilled both the requirements of applicability across outsourcing arrangements and industries. He highlighted that the knowledge framework supports an organisation in identifying knowledge gaps in their outsourcing projects and that it reinforces a more formal outsourcing consideration. He indicated that the knowledge framework extends across the entire lifecycle of outsourcing and the fact that critical success factors are driving focus for each of the outsourcing phases, were the most relevant component. Lastly, he indicated that the knowledge requirements and the knowledge flows provided a comprehensive exposure of all the required outsourcing knowledge management building blocks for all the phases in an outsourcing lifecycle.

DISCUSSION AND CONTRIBUTION

The purpose of the knowledge framework for IS outsourcing presented in this paper is twofold:

1. To guide organisations in their planning when embarking on IS outsourcing with the requirements of creating a shared knowledge base with outsource vendors.
2. To provide organisations with a concrete mechanism, practical steps and validation when embarking on IS outsourcing arrangements.

In order to enable the organisation to conclude a knowledge framework assessment across all phases of an IS outsourcing arrangement, an assessment tool was developed underpinning knowledge framework for IS outsourcing (Figure 2). An organisation can conduct a self-assessment using the assessment tool from which a report, of how well the organisation applies tactical knowledge transfer mechanisms, is produced. Two profiles (lines) are reflected in the feedback report for each IS outsourcing critical success factors, namely the required profile for optimal knowledge application and the organisational profile derived from the assessment questionnaire completed (Figure 3). The gap (the difference between the two lines) shows the critical success factors that must be addressed where the organisation scores lower than the ideal requirement. The tactical knowledge requirements and knowledge flows that must be addressed for each critical success factor can then be highlighted in the assessment report, supporting and guiding an organisation towards a more successful IS outsourcing programme. Also, as alluded to in the introduction, multiple research studies in the past focused on the impact of knowledge-sharing mechanisms on shared knowledge and outsourcing accomplishment, little consideration has been given to theoretical frameworks guiding an understanding of IS outsourcing specifically, or on how organisations manage knowledge in outsourcing circumstances (Beyah & Gallivan, 2001; Blumenberg et al., 2009; McIvor, 2000; Teo, 2012). A need therefore exists for the establishment of a set of tactical mechanisms that may assist organisations during the IS outsource process to ensure that knowledge is properly managed, captured and available.

To address this problem and the specific need for guidance on how to address the critical success factors for IS outsourcing (Smuts et al., 2015a), a knowledge framework for IS outsourcing is proposed in this paper.

CONCLUSION

The paper presented a knowledge framework for IS outsourcing. Based on earlier defined key considerations for IS outsourcing, critical success factors for IS outsourcing were presented for each of the three phases of IS outsourcing, namely architect, engage and govern. Knowledge factors consisting of tactical knowledge requirements and tactical knowledge flows were identified, supporting explicit knowledge exchange, as well as externalisation of tacit knowledge regarding products, mental models, market and needs.

Since the knowledge framework for IS outsourcing guides pertinent activities in the outsourcing programme, the framework could be applied at a practical and operational level by both an organisation launching an IS outsource initiative or an organisation managing an already existing IS outsource arrangement. The objective of applying the knowledge framework is to transform the intellectual assets of an organisation into business value, to change knowledge into competencies and replicate know-how.

The evaluation of the knowledge framework for IS outsourcing highlighted the applicability of the knowledge framework for IS outsourcing in multiple industries and in outsourcing projects other than IS outsourcing. Although the outcome of the evaluation indicates the usefulness of the framework in other domains, further exploration to generalise the findings is suggested as future research.

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APPENDIX - DETAIL of RESULTS

Critical Success Factors

Table 3. Critical success factors for knowledge exchange during the architect phase of IS outsourcing

Critical success factors	References
Access to client organisation key documentation	(Gartner, 2008b; Oza et al., 2004; Smuts et al., 2015b; Sood, 2005)
Business and IS employees understanding and buy-in	(Aalders, 2001; Al-Ahmad & Al-Oqaili, 2013; Alexandrova, 2012; Gonzalez, Gasco, & Llopis, 2005; Jennex & Adelakun, 2014; Olzmann & Wynn, 2012; Vorontsovaa & Rusub, 2014; Yakhlef, 2009)
Implication analysis of outsourcing objectives	(Foogooa, 2008; Lee, 1996; Sood, 2005; Sparrow, 2003)
Integrated IS outsourcing strategy and business strategy	(deSá-Soares, Soares, & Arnaud, 2014; Foogooa, 2008; Gwebu, Wang, & Wang, 2010; Lee, 1996; Sood, 2005; Sparrow, 2003)
Outsourcing skilled client organisation	(Brown & Fersht, 2014; Khalfan & Alshawaf, 2003) (Earl, 1996; Foogooa, 2008)
Parameters for service quality benefits	(Aalders, 2001; Barthélemy & Adsit, 1993; Beyah & Gallivan, 2001; Slaughter & Ang, 1996; Sparrow, 2003)
Quantified business benefits	(Aydin & Bakker, 2008; Gartner, 2008b; Smuts et al., 2015b)
Viable business case	(Akomode, Lees, & Irgens, 1998; Ali & Khan, 2014; Barthélemy & Adsit, 1993; Khalfan & Alshawaf, 2003; Laplante et al., 2004; Vural, 2010)

Table 4. Critical success factors for knowledge exchange during the engage phase of IS outsourcing

Critical success factors	References
Agile procurement process and negotiation	(Aalders, 2001; Fink & Shoeib, 2003; Franceschini, Galetto, Pignatelli, & Varetto, 2003; Gonzalez et al., 2005; Petter Gottschalk & Solli-Sæther, 2005; Lacity & Willcocks, 2009; Lee, 1996; Miozza & Grimshaw, 2005; Pistole & Bragg, 2005)
Arrangement flexibility	(Cullen & Willcocks, 2003; Khalfan & Alshawaf, 2003; Rao, Nam, & Chaudhury, 1996; Slaughter & Ang, 1996; Taylor & Bain, 2009; Varajão et al., 2012; Vilvovsky, 2008)
Clear outsource scope definition	(Aalders, 2001; Al-Ahmad & Al-Oqaili, 2013; Alexandrova, 2012; Ang & Cummings, 1997; Brown & Fersht, 2014; Costa, 2001; Fill & Visser, 2000; Gonzalez et al., 2005; Peter Gottschalk & Solli-Saether, 2006; Gwebu et al., 2010; Laplante et al., 2004; Mazza & Azzali, 2014; Pandey & Bansal, 2003; Yakhlef, 2009)
Clear role and responsibility definition	(Cullen & Willcocks, 2003; Smuts et al., 2015b; Sood, 2005; Sparrow, 2003)
Client organisation knowledge retention plan	(Alexandrova, 2012; Aydin & Bakker, 2008; Jensen, Menon, Mangset, & Dalberg, 2007; Marchewka & Oruganti, 2013; Miozza & Grimshaw, 2005; Nam, Rajagopalan, Rao, & Chaudhury, 1996; Vorontsovaa & Rusub, 2014; Willcocks et al., 2004; Yakhlef, 2009; Yun, 2009)
Definition of delivery performance process	(Aydin & Bakker, 2008; Cullen & Willcocks, 2003; Khalfan & Alshawaf, 2003; Oza et al., 2004; Sood, 2005)
Outsource vendor screening	(Al-Ahmad & Al-Oqaili, 2013; Earl, 1996; Fink & Shoeib, 2003; Franceschini et al., 2003; Gonzalez et al., 2005; Marchewka & Oruganti, 2013; Pistole & Bragg, 2005; Yakhlef, 2009)
Resource mobilisation	(Al-Ahmad & Al-Oqaili, 2013; Alexandrova, 2012; Benamati & Rajkumar, 2002; Brown & Fersht, 2014; Cullen & Willcocks, 2003; Gellings, 2007; Goles & Chin, 2005; Petter Gottschalk & Karlsen, 2005; Petter Gottschalk & Solli-Sæther, 2005; Grover, Cheon, & Teng, 1996; Jensen et al., 2007; Nguyen et al., 2006; PA Consulting Group, 2009; Sabherwal, 1999; Vorontsovaa & Rusub, 2014)
Service level agreement design	(Foogooa, 2008; Gartner, 2008b; Lee, 1996; Sood, 2005; Sparrow, 2003) (Cullen & Willcocks, 2003; Sparrow, 2003)
Service scope flexibility	(Aalders, 2001; Brown & Fersht, 2014; Petter Gottschalk & Solli-Sæther, 2005; PA Consulting Group, 2009; Vorontsovaa & Rusub, 2014)
Up to date organisational and business process knowledge repository	(Alavi & Leidner, 2001; Beyah & Gallivan, 2001; Blumenberg et al., 2009; Foote & Halawi, 2016; Zahedi, Shahin, & AliBabar, 2016)

Table 5. Critical success factors for knowledge exchange during the govern phase of IS outsourcing

Critical success factors	References
Appropriate level of expertise and skill	(Akomode et al., 1998; Brown & Fersht, 2014; Cullen & Willcocks, 2003; Currie, 2000a; Petter Gottschalk & Solli-Sæther, 2005; Jennex & Adelakun, 2014; Lacity & Willcocks, 2009; Oza et al., 2004; Vilvovsky, 2008)
Contract management	(Akomode et al., 1998; Al-Ahmad & Al-Oqaili, 2013; Beaumont & Sohal, 2004; Cullen & Willcocks, 2003; Dibbern, Goles, Hirschheim, & Jayatilaka, 2004; Earl, 1996; Fink & Shoeib, 2003; Foogooa, 2008; Franceschini et al., 2003; Gellings, 2007; Laplante et al., 2004; Marchewka & Oruganti, 2013; Nam et al., 1996; PA Consulting Group, 2009; Smuts, Kotze, Merwe, & Loock, 2010b; Yakhlef, 2009; Zelt et al., 2013)
Cost management	(Brown & Fersht, 2014; Costa, 2001; Cullen & Willcocks, 2003; Petter Gottschalk & Solli-Sæther, 2005; Laplante et al., 2004; Pistole & Bragg, 2005; Soliman, 2003; Taylor & Bain, 2009; Vilvovsky, 2008)
Delivery performance management	(Alexandrova, 2012; Beaumont & Sohal, 2004; Brown & Fersht, 2014; Costa, 2001; Cullen & Willcocks, 2003; Currie, 2000a; Foogooa, 2008; Jensen et al., 2007; Marchewka & Oruganti, 2013; Nguyen et al., 2006; Oza et al., 2004; Smuts et al., 2015b; Soliman, 2003)
Dry-run of business integration plan	(Brown & Fersht, 2014; Costa, 2001; Cullen & Willcocks, 2003; Gonzalez et al., 2005; Vorontsovaa & Rusub, 2014)
Formal change control process	(Costa, 2001; Cullen & Willcocks, 2003; Dibbern et al., 2004; Fink & Shoeib, 2003; Lacity & Willcocks, 2009; Miozza & Grimshaw, 2005; Smuts, Kotzé, Merwe, & Loock, 2010a; Softection, 2009)
Programme control / management, communication and leadership	(Alexandrova, 2012; Cullen & Willcocks, 2003; Gonzalez et al., 2005; Petter Gottschalk & Solli-Sæther, 2005; Jensen et al., 2007; Marchewka & Oruganti, 2013; Nguyen et al., 2006; Oza et al., 2004; Solli-Saether & Gottschalk, 2008; Vorontsovaa & Rusub, 2014; Yun, 2009)
Proper artefact management	(Beyah & Gallivan, 2001; Brito, Figueiredo, Venson, Canedo, & Ribeiro, 2017; Lam & Chua, 2009; Zahedi et al., 2016)
Service integration across outsource arrangement work streams	(Alexandrova, 2012; Claver, Gonzales, Gasco, & Llopis, 2002; Cullen & Willcocks, 2003; Earl, 1996; Gonzalez et al., 2005; Goo, Huang, & Hart, 2008; Marchewka & Oruganti, 2013; Mazza & Azzali, 2014; Miozza & Grimshaw, 2005; Olzmann & Wynn, 2012; Vorontsovaa & Rusub, 2014; Yun, 2009; Zelt et al., 2013)
Service level agreement application	(Al-Ahmad & Al-Oqaili, 2013; Beaumont & Sohal, 2004; Cullen & Willcocks, 2003; Fink & Shoeib, 2003; Franceschini et al., 2003; Goo et al., 2008; Petter Gottschalk & Solli-Sæther, 2005; Jensen et al., 2007; Lam & Chua, 2009; Laplante et al., 2004; Lee, 1996)
Staff management	(Brown & Fersht, 2014; Costa, 2001; Cullen & Willcocks, 2003; Petter Gottschalk & Karlsen, 2005; Petter Gottschalk & Solli-Sæther, 2005; Grover et al., 1996; Slaughter & Ang, 1996; Soliman, 2003)

Knowledge Requirements and Knowledge Flows

Table 6. Tactical mechanisms for knowledge requirements and knowledge flows for the architect phase of IS outsourcing

Critical success factor	Tactical knowledge requirements	Tactical knowledge flows
Access to client organisation key documentation	Identification and documentation of client organisation intellectual property	• Ensure accessibility of documented client organisation knowledge • Ensure that a well-managed client organisation business process knowledge repository is available
Business and IS employees understanding and buy-in	Knowledge of client organisation structures in order to engage with the correct people from the client organisation and outsource vendor.	• Facilitate more interaction between Business, IS and Finance to close / minimise potential disconnect gap
	Understanding of sensitivity around client organisation stakeholder and staff expectations	• Obtain buy-in to the framework used to define the outsource vendor arrangement
Implication analysis of outsourcing objectives	Knowledge of risk related to chosen outsource model e.g. off shore data is a key concern, risk of loss of IP	• Collate research and intelligence on outsource models
	Market knowledge	• Conduct live demonstrations and presentations of the current challenges in client organisation • Collate research and intelligence on shortlisted vendors and outsource models (i.e. onshore, nearshore, offshore, hybrid etc.)
Integrated IS outsourcing strategy and business strategy	Knowledge of the operations, in order to derive operational type benefits which can also be lifted up to a strategic level.	• Establish business decision making process in support of outsourcing as a business strategy
	Market knowledge	• Knowledge of all the facts before the outsourcing decision is taken as a strategic direction • Conduct proper due diligence of the function / work to be outsourced
Outsourcing skilled client organisation	Knowledge of client organisation structures in order to engage with the correct people from the client organisation and outsource vendor.	• Define key manpower resources required to select the outsource vendor • Conduct skills comparison to internal skills database before considering external skills from outsource vendor • Create a comprehensive skills database of existing internal resources in client organisation
	Market knowledge	• Consider whether or not to use external adjudication of outsource decision
	Understanding of sensitivity around client organisation stakeholder and staff expectations	• Ensure that external skills from outsource vendor directly address gaps, be complementary and work alongside existing (similar or developing) skill-sets
	Up-skilling of and knowledge sharing with the client organisation on outsource implications and management	• Involve key resources in the client organisation early on in the process (from the beginning) • Train and transfer knowledge to client organisation employees on outsource management and joint execution
Parameters for service quality benefits	Benchmarking and performance measures	• Access to benchmarking repository
	Consider key elements that must be reflected in the business case	• Defining knowledge transfer as a key objective in the business case, with specific reference to post implementation adoption, support and maintenance of the solution.
	Knowledge of the operations, in order to derive operational type benefits which can also be lifted up to a strategic level.	• Plan the work contribution of the outsource arrangement with appropriate stakeholders.
Quantified business benefits	Benchmarking and performance measures	• Define accurate performance measures and benchmarks for outsource arrangement
	Consider key elements that must be reflected in the business case	• Quantify the business case with tangible measures
Viable business case	Knowledge of the various cost factors must be considered in terms of development / deployment costs & ongoing costs with a specific emphasis on License costs, Human Resource Costs, Hardware Infrastructure Costs, etc.	• Share good and sufficient activity based costing information • Ensure proper cost benefit analysis is concluded
	Understanding of sensitivity around client organisation stakeholder and staff expectations	• Obtain formal Board / Executive approval of business case

Table 7. Tactical mechanisms for knowledge requirements and knowledge flows for the engage phase of IS outsourcing

Critical success factor	Tactical knowledge requirements	Tactical knowledge flows
Agile procurement process and negotiation	Knowledge of outsourcing processes and governance	• Define agile and best practice procurement processes for outsource vender evaluation and selection
		• Agree process of formal guarantees, warranties and acceptance by outsource vendor
	Knowledge of required scope of outsourcing	• Define clear scope and knowledge of client organisation negotiation position
	Negotiation skills and knowledge of negotiation position	• Knowledge of vendor/supplier capabilities and experiences will assist in the establishment of contracts and governance roles within the outsourcing arrangement
Arrangement flexibility	Knowledge of the areas that are core and that need innovation	• Outcome based analysis on usability of the end product produced, using Key Performance Indicators set during the Request for Proposal phase
Clear outsource scope definition	Formal records management	• Publish auditable outsource vendor evaluation outcome • Obtain formal approval of negotiated outsource contract and award of work to outsource vendor • Agree formal payment profile per milestone with formal acceptance criteria with the outsource vendor
	Knowledge of required scope of outsourcing	• Define comprehensive and properly defined Request for Proposal
	Proper and realistic project planning	• Agree action plan, delivery plan and project plan
Clear role and responsibility definition	Negotiation skills and knowledge of negotiation position	• Establish credibility of shortlisted vendor contact people / negotiation team
	Outsource management skilled client organisation	• Stakeholder management knowledge as business relationships take time to develop as does the internal cultural requirements of the client and outsource vendor organisation. • Create a small senior empowered team for outsource vendor evaluation and selection • Train and transfer knowledge to client organisation employees on outsource management and joint execution. • Agree involvement of an external specialist support body (e.g. legal, audit) to assist ad hoc when required

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Table 7 conintued

Critical success factor	Tactical knowledge requirements	Tactical knowledge flows
Client organisation knowledge retention plan	Define model for retaining key knowledge and skill in organisation	• Knowledge framework agreed and documented in early stages of outsource process
	Define model for retaining key knowledge and skill in organisation	• Unpacking the key objective of knowledge transfer into measurable services and products to be included in the criteria for vendor selection and contract negotiation.
	Define model for retaining key knowledge and skill in organisation	• Utilise defined and appropriately transparent knowledge transfer channels, where client organisation stakeholders are kept up to date on the processes used and rationale for vendor selection and subsequent contract terms.
Definition of delivery performance process	Knowledge of outsourcing processes and governance	• Understanding of industry norms and trends will provide better insight into sourcing arrangements. • Access to solution benchmarking repository
Outsource vendor screening	Knowledge of outsourcing processes and governance	• Consult Subject Matter Expert's knowledge base for outsource vendor evaluation and selection
	Knowledge of the objectives and mutual benefits of the parties involved	• Communicate, in the client organisation, the framework used to select the outsource vendor
	Outsource vendor knowledge and their ability to evolve and offer better services	• Create knowledge management repository of preferred vendor information • Ensure availability of vendor experiential information (white papers of previous outsource arrangements for vendor)
	Supplier knowledge and their ability to evolve and offer better services	• Establish if vendor has leading subject knowledge, skill and experience. • Facilitate proof of concept and demonstrations in the client organisation by outsource vendors on the short list
Resource mobilisation	Knowledge of the time taken for resources to be mobilised	• Plan for ramp up time of client organisation and outsource vendor manpower resources
Service level agreement design	Knowledge of Service Level Agreements	• Agree performance measures and benchmarks for outsource arrangement • Ensure well defined Service Level Agreements
Service scope flexibility	Outsource vendor knowledge and their ability to evolve and offer better services	• Conduct knowledge sharing session with current customers of outsource vendors on the short list
Up to date organisational and business process knowledge repository	Create knowledge repository for organisational key knowledge (people, system, process)	• Create / make available knowledge base of lessons learnt on similar activities • Access to a knowledge base of client organisation information • Transparent and easy access to client organisation data • Ensure proper and sufficiently defined client organisation documentation is available prior to engaging the outsource vendor

Table 8. Tactical mechanisms for knowledge requirements and knowledge flows for the govern phase of IS outsourcing

Critical success factor	Tactical knowledge requirements	Tactical knowledge flows
Appropriate level of expertise and skill	Contract management skills and knowledge	• Create a mandated and knowledgeable client organisation IS outsourcing decision making body
	Joint execution key drivers and process	• Conduct formal knowledge transfer workshops between client organisation and outsource vendor
	Maintain knowledge repository for organisational key knowledge i.e. business requirements and solution design	• Determine key knowledge gaps in the client organisation and formalise how the knowledge in these areas would be addressed • Conducting formal knowledge transfer workshops of learning that has taken place • Facilitate knowledge sharing sessions with Subject Matter Expert from outsource vendor with specific agenda and objectives
	Outsource operational management skills	• Build key skills to manage an outsource partner relationship, formal Service Level Agreements, strong relationship management and building of firm commercial knowledge.
Contract management	Financial and cost management skills	• Create a team that manages/monitors the outsource vendor that is not involved in the day to day running of the outsource project • Establish client organisation own monitoring capabilities as well establishing governance structures to manage the outsource vendor
	Internal policy and procedures of client organisation	• Understanding of client organisation internal policy and procedure e.g. procurement, purchase order, recruitment etc.
	Joint execution key drivers and process	• Ensure direct access between outsource partner team leaders and business users
	Knowledge of critical metrics in relation to the operational environment to measure performance	• Access to benchmarking repository
	Maintain knowledge repository for organisational key knowledge i.e. business requirements and solution design	• Well documented business processes, policies and procedures across the client organisation operations (i.e. broader than IT)
	Project management skills and knowledge	• Create / make available knowledge base of lessons learnt on similar activities
Cost management	Delivery traceability matrix	• Client organisation to monitor benefit realisation within the outsource arrangement
Delivery performance management	Knowledge of critical metrics in relation to the operational environment to measure performance	• Ensure well defined measureable business benefits linked to well defined and measureable business processes. • Knowledge transfer of key benchmarking that is done i.e. best practices specific to industry • Define outsource vendor performance detail in order to measure effectively
	Maintain knowledge repository for organisational key knowledge i.e. business requirements and solution design	• Ensure that a proper knowledge management system to document processes is available
	Outsource operational management skills	• Access to knowledge base of outsource vendor previous experience • Knowledge transfer of SLA monitoring specific to the outsource model and how it should be maintained to the benefit of the organisation
	Strict contract management (rules of the game), governance re commercials, milestones and performance	• Access to the actual operational areas/people that the outsource arrangement will impact.
Dry-run of business integration plan	Project management skills and knowledge	• Plan for sufficient and formal hand over time
Formal change control process	Maintain knowledge repository for organisational key knowledge i.e. business requirements and solution design	• Define formal mechanisms through which outsource vendor can transfer knowledge to the client organisation

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Table 8 conintued

Critical success factor	Tactical knowledge requirements	Tactical knowledge flows
Programme control / management, communication and leadership	Contract management skills and knowledge	• Iterative detailed update to all members of the team, as the strategy changes or items become apparent that change the course of the project.
	Joint execution key drivers and process	• Create shared office space between internal project resources and outsourced project resources • Create a common knowledge repository between client organisation and outsource vendor as part of the outsource arrangement
	Project management skills and knowledge	• Consider impact of scope on data integrity, data migration and data readiness in new solution to enable business benefits • Common understanding of status between client organisation and outsource partner that could be represented graphically through status dashboards, checklists, etc. • Planning of the work required and correct resource allocation with appropriate client organisation and outsource vendor stakeholders. • Defined project governance process and procedure must include oversight and control of knowledge management flows
	Strict contract management (rules of the game), governance re commercials, milestones and performance	• Clear communication of expectations, and timelines for service delivery by client organisation
Proper artefact management	Joint execution key drivers and process	• Access to knowledge base of reference models • Utilise joint documentation responsibilities between client organisation and outsource vendor
	Maintain knowledge repository for organisational key knowledge i.e. business requirements and solution design	• Proper focus group meetings where all key stakeholders are mandated to attend and participate and a central document repository to ensure transparency to all participants in the process.
Service integration across outsource arrangement work streams	Delivery traceability matrix	• Facilitate proof of concept and demonstrations of the solution
	Joint execution key drivers and process	• Utilise key expert knowledge formally through consulting and access through a cross functional team set up to define and drive the knowledge sharing process.
	Maintain knowledge repository for organisational key knowledge i.e. business requirements and solution design	• Client organisation to share all information required by outsource vendor in transparent and trusting manner
	Outsource operational management skills	• Operational integration and expectation sessions discussing KPI's and alignment between coming outsource stages.
	Project management skills and knowledge	• Facilitate integration sessions across outsource arrangement work streams e.g. technical, programme, business
Service level agreement application	Knowledge of SLA agreements	• Define initial stabilisation period for Service Level Agreement threshold • Establish a cross functional team to evaluate all aspects of outsource vendor delivery including business, IT, legal, finance and HR.
Staff management	Joint execution key drivers and process	• Facilitate joint execution between outsource vendor and client organisation resources
	Knowledge of escalation paths within the supplier organisation for problem resolution	• Agree way of working with outsource vendor and 3rd party vendors
	Outsource operational management skills	• Foster a culture of knowledge sharing
	Project management skills and knowledge	• Form one team with outsource vendor

Chapter 11
Data in the Wild:
A KM Approach to Collecting Census Data Without Surveying the Population and the Issue of Data Privacy

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ABSTRACT

Knowledge Societies strive to better their citizens by maximizing services while minimizing costs. One of the more expensive activities is conducting a census. This chapter explores the feasibility of conducting a smart census by using a knowledge management strategy of focusing on actionable intelligence and the use of open source data sources to conduct a national census that collects data to answer the issues the census is designed to address. Both technical and data privacy feasibility is discussed.

DOI: 10.4018/978-1-7998-2355-1.ch011

INTRODUCTION

The federal government collects data on the population of the United States to fulfill its constitutional requirement to count and analyze the population every ten years in order to determine the number of seats each state has in the U.S. House of Representatives, distribute billions in federal funds to local communities, and other statistical purposes. As the amount of data collected grows it fuels advances in technology with respect to counting and processing the census data. Unfortunately, new technology for identifying, collecting, and then sharing the census data has yet to be adopted (United States Census Bureau, n.d.a), forcing some data to be collected numerous times at varying levels of accuracy. Gromme (2018) discusses Europe's attempts at utilizing Facebook as a source for generating a census but recognizes there are many problems with Facebook. This paper agrees with Gromme (2018) and so proposes to use existing web-based sources, including social computing sources, instead of paper surveys. To show that this is a feasible approach, we analyze current government data collection and analysis efforts, suggest alternate data sources and propose a strategy for an open source system of population statistics. Our study indicates that a strategy that is based on open source data could generate better focused and actionable intelligence as well as improve the cost, accuracy, efficiency, timeliness, and collaborative efforts of the census. Specifically, we show how an actionable intelligence strategy is created using current and proposed data sources that can help answer complex questions such as what poverty is, and a new way to analyze income by using take home pay instead of gross dollar amounts. Lastly, this study proposes a set of data standards for supporting development of an open source census system that also addresses data privacy.

RESEARCH MOTIVATION

Why do we need a new approach to census data collection? First, the census is expensive. The reported cost of the 2010 census was approximately $13 Billion (United States Government Accountability Office,.2011). The 2020 Census, if administered the same way, will cost approximately $17.5 Billion (House Oversight Committee, 2017; Scherer and Bahrampour, 2017). Along with the census costs, the American Community Survey (ACS) (a newer development discussed later) costs as much as $204 million per year to administer (Griffin, 2011). The proposed strategy would drastically cut costs by using existing open source data sets as well as existing government raw data to reduce or eliminate collecting similar or identical information through Census surveys or the ACS. The US Census Bureau would also begin to utilize state information databases to cut down on its data collection efforts. California and Hawaii have robust websites with information on their specific states already in use, making some of the data the census and ACS currently collects redundant for those states.

Second, the census is not accurate. Accuracy is crucial for decision making. Unfortunately, the census may be inaccurate as most of the questions on the ACS have the potential to produce inaccurate information because of the design of the questions and the way answers are provided. Specifically, most questions about annual income and monthly and annual expenses are answered by providing write in totals. This has the potential of producing data that is not accurate as people have no incentive to be exact when answering the questions nor do they know exactly how much they spend. In addition, the data provided is not checked against any other systems to determine the data's accuracy. The length of the survey (consisting of a minimum of 11 pages and 48 questions per member of a household with multiple parts to majority of the questions) introduces fatigue. Thus, if options exist for automated data collection, self-reporting and long surveys should not be the first choice. A more accurate alternative to survey data is open source or other data sources. For example, utility companies have a vested interest in keeping accurate information for billing purposes, and banks have a vested interest in keeping accurate track of how much money their clients have on account.

Third, the census is inefficient as the same data is collected more than once. The ACS attempts to collect information that has already been obtained by other means and other departments of the federal government. The best example of this is the IRS not sharing income data with the Census Bureau, thus forcing the Census Bureau to collect less accurate information than that the IRS already has in its possession (Card, et al., 2011). The strategy outlined in this paper calls for performing data collection once by allowing government agencies and other entities to share data in a centralized location.

Fourth, the census in not timely. It takes an average of 9 months for both the Census Bureau (collection happens every 10 years) and the ACS (annual collection) to release its first data files after collection. Despite how quickly the results can be tabulated the issue is that the time periods between the surveys are too long. There are important developments that are missed during a 1 or 10-year survey period that could help in creating actionable intelligence. A better strategy is to collect as often as feasible, even on a continuous basis. A perpetually updated, dashboard style reporting system would create timely data for development of actionable intelligence.

Fifth, there is little collaboration between data owners and census takers. Collaboration with groups that specialize in specific types of data collections (IRS – gross income, income sources, tax credits and tax liability, Insurance Agencies – property values, cars) or with different government agencies that maintain data sets on specific types of data has the potential to create powerful analysis about population statistics that can be turned into actionable intelligence. Currently raw IRS income data is restricted and not easily obtained (Mervis, 2014). Our strategy calls for multiple government agencies, local governments, private and public companies to share information in an open source format to share with each other and the public to perform analysis and create actionable data. The Digital Accountability and Transparency Act of 2014 already requires the issuance of guidance to federal agencies on such data standards (Digital Accountability and Transparency Act of 2014, 2014.). The federal government should engage with public and private institutions on not just establishment of standards, but also in collecting data and developing more collaborative strategies for collecting data that could help improve the quality and timeliness of data.

Sixth, the census is manual. The census should be automatic as there are cases where data can be easily obtained from existing datasets for a secondary purpose. Edwin Black in "IBM and the Holocaust" explored the tremendous impact on the ability of the Nazi regime to identify and exterminate persons of Jewish origin or heritage through the application of IBM's Hollerith Card technology originally developed and applied to the United States Census (Black, 2001). Additionally, it has been shown how the Obama campaign used Facebook data to influence voters in the 2012 presidential election. Finally, recent revelations in testimony to the United States Congress by Mark Zuckerberg, Chief Executive Officer of Facebook, showed how Facebook data was obtained by the Trump campaign for potential use in targeted marketing of voters (Kozlowska and Timmons, 2018). While these examples raise privacy issues and may be looked at as negative, they provide a proof that automatic collection of information is already happening. The goal should be to use this automatic collection in an ethical way that does not violate data privacy of each individual in the population of the US.

In sum, the previous discussion shows that the census information, as collected today, has major disadvantages. This paper proposes a knowledge management, KM, strategy approach to create actionable intelligence for guiding a census using already existing open source data that are less costly, more accurate and efficient, timely, allow for better collaboration between data owners and census takers, and automatic. Given that we propose automatic collection of data that may lead to negative side-effects (such as the recent Facebook example of targeted marketing to different demographic groups prior to the 2018 presidential election), the paper will begin the discussion on the impact on privacy that such an approach may create. Our goal is to suggest a technology that takes data privacy into account during the development stage rather than as an afterthought while keeping the goal of the creation of actionable intelligence from the data that is being collected on the US population.

THE UNITED STATES CENSUS

The US census has one constitutional purpose, which is to count the population of the United States every ten years, according to Article 1, Section 2 of the Constitution (United States Census Bureau, 2011). This number is used for congressional apportionment to each state based on population. The Census Bureau has also taken on the task, though not required by the Constitution, of collecting data other than a straight population count which is apparent by the questions that are asked in historical census and the new ACS. Before the invention of the Internet, personal computers, and other more recent advances in computing power and technology, the census survey was one of the only ways of collecting any sort of data on the population of the United States. In today's high-tech world there have been numerous technological advances that would allow more robust data collection at a faster rate with more accuracy, than the methods that have been and are currently being used by the Census bureau. The population of the United States has grown from 3,929,326 in 1790 (United States Census Bureau, n.d.a) when the first census was completed to 308,745,538 as of 2010 census, the most recent completed census (United States Census Bureau, n.d.b). The United States of America is simply too large of a population to not be using more advanced data analytics, systems design and KM techniques. Not only does the census bureau have a difficult mission in collecting accurate data on the entire population in its current form, the data it is able to collect is less useful in making decisions, creating policy and helping to manage the huge amounts of resources under the control of the federal government which are estimated at an annual budget of 4.4 trillion and assets of 3.5 trillion (Malenich and Dacey, 2017).

Additionally, federal data requirements have changed with the addition of an annual survey in 2005. This survey, the ACS, uses statistical modeling to estimate the data that was normally collected on the long form census and goes to an estimated 1 in 6 families each year without repetition for those families in a 5-year period (United States Census Bureau, n.d.c). While this was a step in the right direction with respect to timeliness, the problem remains that the ACS still asks questions with little or no analytical value in helping to produce valuable actionable intelligence by policy makers. Moreover, the method of collection, a paper survey, has remained mostly unchanged throughout the history of the census. This survey is mailed to all households in the United States. Follow up is done on people that do not answer the survey and census workers go door to door if necessary to get the survey completed (United States Census Bureau, 2010). This is a very inefficient and expensive way to collect data with costs as stated in section 2.

While the Census Bureau has added technological advances, such as ocular character recognition to help cut down on data entry errors and personnel that help tabulate the results and count more efficiently (United States Census Bureau, n.d.d), these changes can be considered worthwhile in a short run rather than long term solutions. private companies have embraced advanced data analytics and big data solutions while the government has not yet done so. The Federal government has much more opportunity to effect change in this area of technological advances than any other company or group in the United States. Many industries like health care, marketing and finance have taken data analytics to a whole new level in just the last 5 years. Big data is trending, schools are creating programs based on analytics and thousands of books have been written on the subject, big data in its current form started in 2007 (Marr, 2015). The federal government can collect more good quality data than any other organization and at a lower cost than what is being spent on data with questionable value, by following the lead of organizations in for profit and nonprofit industries. The next section describes a potential solution to automated census data collection named social computing.

Social Computing

Social computing is as an umbrella term for research and development at the intersection of computer science and social science (Manovich, 2016). It is defined as computational facilitation of social research and development using information and communication technologies driven by three major needs in social context: (a) develop better social software to facilitate interaction and communication, (b) digitalize some aspects of human society and social dynamic, and (c) analyze and predict social and cultural behavior (Wang et al., 2007). Social computing rests on the foundation of various fields from social psychology to ubiquitous computing and it is enabled by numerous technologies from social media technology to the Internet of Things (IoT). The broad applications of social computing also span diverse disciplines such as education (Eid and Al-Jabri, 2016.), organizational science (Stokic et al., 2013), product development (Evans et al., 2015.), transpiration (Ning et al., 2017), digital humanities (Manovich, 2016) and of course, social networking (Tehone et al., 2015).

Social Computing advancement is still a mere computing innovation in social software than social mechanisms (Bogolyubov and Komarov, 2013). For a decade, research in this domain was dominated by the technical discussions, and applications are limited to social software such as social media. Only recently, a notable shift towards more complex social challenges and integration of social mechanisms could be observed. To reach its full potential, social computing should inevitably include more social dimensions. Otherwise, it would fall short in systematically addressing social challenges and affording new opportunities. This study is a contribution to this line of research by offering an alternative approach to one of the indispensable necessities for government programs, policies and decision-making: national censuses. The potential role of social computing —in terms of both technologies and strategies— in improving the national census process is often overlooked and surprisingly understudied. To address this gap, we first discuss the role of social intelligence in e-government and then present how it can be utilized in the census process.

Social Intelligence and e-Government

Social computing enables new business models such as social media, social commerce, and social manufacturing while redefining computing in various industries from video game to electronic government (Wang et al., 2007; Zhang et al., 2018). Recent development in social computing has also affected public services including healthcare, law enforcement, and emergency services with significant societal impact (Wang et al., 2007; Zhang et al., 2018). Among these areas, e-government has received far less attention and applications in this area have been limited to predictive systems for a few use cases such as counter-terrorism, epidemiology, and disaster management.

Social computing, compared with traditional computing, is more dynamic, integratable, interoperable and portable (Parameswaran and Whinston, 2007). Therefore, it provides more opportunities for redefining e-government services to citizens, government agencies, and businesses (Joseph, 2009). In this domain, social intelligence has become a focal point of social computing research in e-government area. Social intelligence systems provide actionable data based on attributes, opinion, and attitudes of social actors (Dinter and Lorenz, 2012.). These systems not only enable social enterprises but also broadens social information creation, circulation, and consumptions (Wang et al., 2018). They also mitigate some challenges with social information asymmetry as well as accessibility, accuracy, and timeliness (Parameswaran and Whinston, 2007). Research showed that the integration of social intelligence into decision systems has a significant impact (Dinter and Lorenz, 2012.). Social intelligence systems also enhance open collaboration and knowledge sharing, thereby, encouraging creativity and social ideation (Linders, 2012).

Despite the growing interest in social intelligence systems, there is a lack of systematic characterization of their possible applications (Li and Joshi, 2012). In the e-government context, the full potential of social intelligence systems has not yet been fully understood, let alone realized. Therefore, many research questions in the application areas still remain open or are not yet formulated (Dinter and Lorenz, 2012.).

Social Intelligence and National Censuses

Social intelligence systems can be represented by three key topics that all are associated with knowledge management, namely Knowledge Discovery, Knowledge Sharing, and Content Management (Li and Joshi, 2012). Knowledge discovery mainly refers to knowledge and data mining which in theory can simplify national censuses by minimizing data collection. With the availability of social data new or extended data products and services can be also offered through systematic social mining. Knowledge sharing falls under pervasive computing (ubiquitous computing) with three potential contributions to the census process: (a) promote collective intelligence through interorganizational knowledge sharing between federal agencies, state governments, public entities, and local authorities; (b) facilities data collections from connected devices; and (c) define procedure to protect privacy and access control (Li and Joshi, 2012). Content management emphasizes the management of unstructured and semi-structured social data such as text and sensor-data using collective tagging mechanisms, geo-tagging, and text-mining. Understanding these three areas would bring some clarity to the role of social intelligence in redefining the national census process.

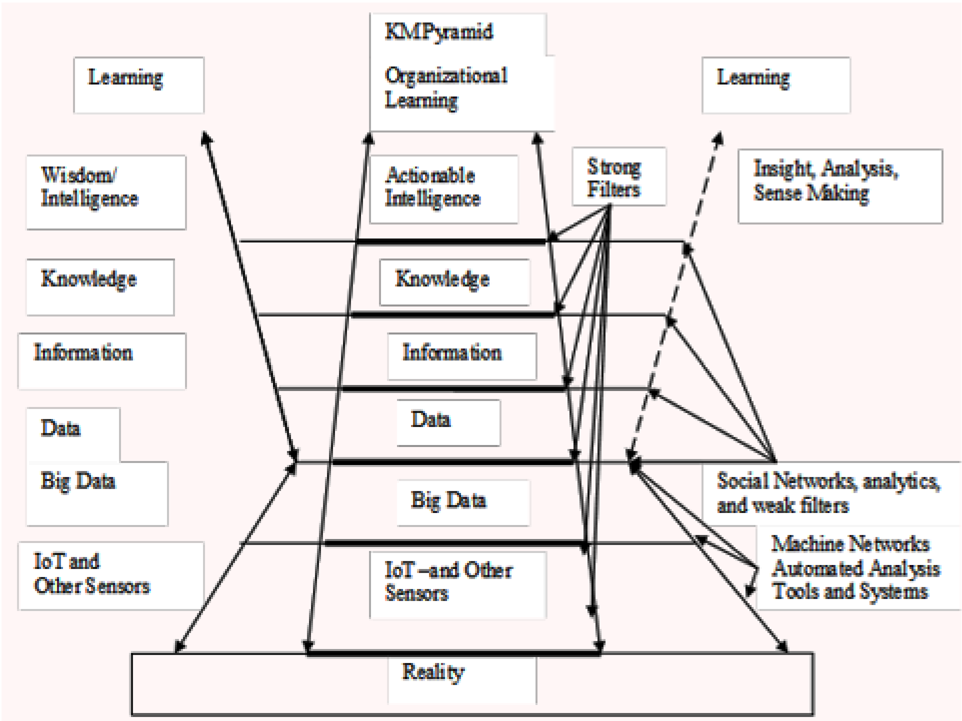
Social computing literature suggests four research avenues to realize the value of social intelligence in knowledge discovery, sharing, and management (Dinter and Lorenz, 2012.). Firstly, while access to social data such as location, identity, mobility patterns, and social connections is possible, social data architecture and management are yet to be defined. Adding social data to the pool of available data for analysis can minimize the cost of data collection and define new use cases. However, there is a broad range of design questions in preparing social data that have to be addressed (e.g. data security, metadata framework, and data quality management). Hence, new processes for public and private data integration, blending, mapping and sharing need to be designed and deployed. Secondly, the challenge to identify appropriate data sources, as well as the legal and quality aspects, need to be addressed (Dinter and Lorenz, 2012.). For example, the dataset collected and maintained by different federal and state agencies needs to be identified, evaluated and then blended with social data. Potential limitations regarding data quality, privacy and security also require close attention (Logan, 2018). Thirdly, new information technologies and analytical procedures need to be introduced (Zhang et al., 2018). For example, new data analysis algorithms, and data integration technologies are needed to handle the high data volumes and frequent update rates of social data. Unstructured social data also requires specific software programs for data processing. This results in considerable research demand for data analysis techniques (Dinter and Lorenz, 2012.). Lastly, the integration of social data in the census process might demand new roles and responsibilities and as a result, new data governance principles and guidelines. The new data governance should also address issues such as transparency, interactivity, and participatory nature of social data acquisition and management (Lee and Kwak, 2012).

ACTIONABLE INTELLIGENCE

This paper uses a KM strategy approach to determine data sources useful for generating the census. Jennex (2017) defined the knowledge content process of KM strategy as the identification of *actionable intelligence* needed to make a specific decision and then determining what knowledge, information, and data is needed to create that actionable intelligence. For this paper, actionable intelligence is the exact knowledge, information, and data needed to support a specific census question/decision and includes the specific knowledge, information, and data needed to create the actionable intelligence (Jennex, 2017, 2017a). In general, actionable intelligence is similar to wisdom in the traditional hierarchy of information first presented by Ackoff (1989) as shown in the final revised knowledge pyramid, see Figure 1 (Jennex, 2017a). This model establishes a top down strategy approach based on the decisions to be made and identifying the technologies and decision support components needed. Creating actionable intelligence starts at the top and emphasizes the question that is being asked before deciding which data to collect and from where (Jennex, 2017a). This not only focuses the data collection on the problem to be solved but it also eliminates unnecessary data collection, saving time, money and bolstering data privacy strategies. To apply this to the census we first determined what each census question was trying to answer and then the actionable intelligence needed to generate the answer. Analysis then continued to determine what knowledge, information, and data was needed to create this actionable intelligence.

KM strategy is being used because what is provided by the ACS, the short form census and the Statistics of Income, SOI, annual reports is best labeled as information or data. This is useful for trend analysis and asking question like what is the average income tax expense on a tax return for reporting income between $40,000.00 and $50,000.00 per year? Or what percentage of the US population has a sink with a faucet in their home in 2010? The answers to both questions are simple and easy to find with the existing data sets. What someone can do with those answers is what sets wisdom or actionable intelligence and information/data apart. A question that could only be answered with more advanced data collections and the creation of actionable intelligence would be; what is the solution for poverty in a specific geographical area or demographic? How does poverty present itself in our current data sets? This question cannot be answered with a set of trend data. The answer would require the collection of advanced data and further study and application of

Figure 1. The revised knowledge pyramid (Jennex, 2017a)



knowledge about social programs, government resource limitations, past success in raising families out of poverty as well as privacy policies for data and legal restriction. Another issue is that questions were not specifically linked to the problems needing to be solved when developing the ACS, the short form census or the SOI annual reports. The current approach is inconsistent because the government agencies in charge are collecting data to report to the public as opposed to solving problems.

DATA PRIVACY IMPLICATIONS

The increased use of connected devices utilizing IoT, and associated data collection and data usage have generated data privacy concerns with 74% of Americans saying it is very important for them to be in control of who can get information about them (Rainie, 2016) and thus have access to Personally Identifiable Information (PII). What is PII? According to the department of labor "Any representation of information that permits the identity of an individual to whom the information applies to be reasonably inferred by either direct or indirect means. Further, PII is defined as information: (i) that directly identifies an individual (e.g., name, address, social security number or other identifying number or code, telephone number, email address, etc.) or (ii) by which an agency intends to identify specific individuals in conjunction with other data elements, so-called indirect identification (these data elements may include a combination of gender, race, birth date, geographic indicator, and other descriptors). Additionally, information permitting the physical or online contacting of a specific individual is the same as PII. This information can be maintained in either paper, electronic or other media" (Department of Labor, n.d.).

Major data privacy breaches since 2013 including Target, Uber, and Equifax have further increased public awareness of privacy issues (Armerding, 2017) with data collected by many organizations in the United States, including but not limited to websites like Facebook and Amazon, government agencies, credit bureaus and telecommunications companies. An open source data system could create major problems with data collections of personal information or information that is able to be traced back to the original subject even after personal data is stripped from the published data. Hackers and criminals have grown sophisticated enough to bypass even some of the best secure systems including government agencies like the IRS in 2015 (McCoy, 2016). Privacy is a big issue that needs to be considered when attempting to create any large data system that includes potentially private data. This open source data model will address the issue of data protection and privacy in the three following ways.

First, all data submitted and published for public consumption will have to have all PII stripped from the original data before it is accepted and published. Only meta data will be allowed to be included in the system. For example, IRS submits raw tax return information for the tax year 2015. The data including names, address, social security numbers, business names and any other information included on the return will need to be taken off the data set (a neutral unique identifier for record tracking will have to be used as the primary key for each record). The remaining data should be line by line items or aggregated items to make tracing the data back almost impossible.

Second, privacy can be protected by not giving any original data with PII to the agency or organization that controls the meta data. In the example above the agency maintaining the open source system would not have any risk of a breach effecting the personal information of the data since they didn't have it in the first place. The open source data system is simply a roll up of all the summary data from various sources. This is not as important for data that is already public but would be crucial for data that includes PII in the original data sets like banking records, tax returns etc. It would be crucial when combining several data sets that have a public and private mix. Surprisingly, very few pieces of information are needed to identify individuals in the United States. For example, 5-digit zip, data of birth and gender could be used to identify 87% of the population. Place, gender and date of birth could be used to identify 53% of the population and county, gender and date of birth could be used to identify roughly 18% of the population (Sweeney, 2000).

Third, only knowledge, data, and information necessary to create actionable intelligence should be included in any meta data to avoid possible reverse engineering of original data from meta data sets. The General Data Protection Regulation (GDPR) can be used as a guide for keeping personal data private and untraceable. GDPR is a European Union regulation that helps to protect private data held by companies that operate in the European Union. GDPR became law on May 25, 2018. It is designed so that data cannot be traced back to the original person that provided the data or the subject of the data.

Debate on data privacy escalated on April 10 and 11, 2018, when Mark Zuckerberg, Chief Executive Officer of Facebook, testified before the United States Congress on data privacy and other issues raised following the disclosure that Cambridge Analytica obtained Facebook member data and used it to aid in election advertising for conservative candidates in the 2016 US presidential elections. (Kozlowska and Timmons, 2018). While congress and the public gave the appearance that this was an unethical use of personal data there is evidence to support that the public did not care. There was much celebration in the data analytics community following the 2012 presidential election when data analysts working with the Obama campaign made that campaign the first to use data analytics to drive campaign strategy and marketing (Pilkington and Michel, 2012). While the resulting Obama victory was wildly hailed as a victory for data analytics which the data scientists celebrated, the announcement that the Trump campaign had done essentially the same thing in 2016 was roundly criticized (Editorial Staff, 2018.). Was this a real change in public opinion on data privacy? Evidence may suggest not, as people increased their Facebook usage following Zuckerberg's congressional testimony (Kanter, 2018). Our conclusion is that while the privacy debate is raging, citizens of the United States are not so enamored with data privacy to prevent an open source, actionable intelligence-based approach to a census as a viable alternative.

POSSIBLE DIRECTION FOR THE CREATION OF ACTIONABLE INTELLIGENCE

The United States government does not have a central statistics agency, each department collects and analyzes its own data and does not necessarily share that data with other departments or agencies. This sort of lose knit or decentralized data collections and analysis process lacks an overriding strategy and a set of goals for what they hope to achieve with data collection and analysis. Most of the data collected is centered around trend analysis which does not create the kind of actionable intelligence that can be used to create solutions based on fact. Trend data can be taken out of context easily, or misinterpreted. The proposed strategy advocates collecting data with the intention of providing clear pictures of reality, using multiple sources of differing information and painting a broad picture with context and facts of the overall population of the United States. Below is an example of why trend analysis and the current government data collection process can easily be misleading and misinterpreted. Census data about income is incomplete, the ACS asks about gross income information in the income section of the survey. This does not produce take home pay which can have a wide variance depending on the make-up of a household. Note the following examples of the same size household with different marital status'.

- **Example 1:** Two adults unmarried each with one child making $50,000 per year each. In this situation let us assume that the adults do not comingle funds, share a bedroom and are not in a relationship and both are able to file head of household.
- **Example 2:** Two adults married with 2 children making $50,000 per year each.
- **Example 3:** Two adults unmarried each with one child making $50,000 per year each. In this situation let us assume that the adults are in a relationship comingle funds and only one can file Head of Household filing status.

Table 1 summarizes the federal tax calculations. Note that had the ACS gathered the data in Table 1, the incomes would have an average of $100,000.00 per year per household without considering the bottom line number of what the "household" takes home in net pay.

Table 1. Federal income tax calculation (Using Federal 2016 Tax Tables (Internal Revenue Service, 2016)

	Example 1	Example 2	Example 3
Income	$100,000.00	$100,000.00	$100,000.00
Standard deduction	$(18,700.00)	$(12,700.00)	$(15,700.00)
Exemptions	$(16,200.00)	$(16,200.00)	$(16,200.00)
Table income*	$65,100.00	$71,100.00	$68,100.00
Tax	$(8,342.00)	$(9,734.00)	$(9,036.00)
Net Pay **	$56,758.00	$61,366.00	$59,064.00

* taxable income for example 1 and 3 is calculated in 2 separate returns using combined totals.
**for purposes of this example net pay is before state and local tax, SSI and Medicare and ignores tax credits.

RECOMMENDATIONS

Proposed Actionable Intelligence Strategy Goals

To create a system that fulfills the needs of multiple independent parties, government and the public the following broad strategic goals are proposed.

Goal 1: The system is available to anyone to create reports, aid in research and help to develop actionable intelligence for the development of solutions to the problems associated with population statistics.

Goal 2: The system allows for working with raw data from multiple sources which can be updated on a continuous basis as well as other increments of time depending on the data. Discrete historical data could also be included for context creation and comparisons.

Goal 3: The system allows for maximum flexibility and transparency while maintaining the privacy of PII.

Goal 4: The system will maintain privacy by providing raw data that cannot be traced back to individuals within the data sets using either sources in this system or combining other data sets.

Goal 5: System transparency is on a scale with privacy, the more transparency provided the more likely privacy can be compromised. This scale should be weighted heavier towards privacy than transparency to ensure that privacy is protected.

Goal 6: Data warehouse design should be used to store all data in one place and following industry best practices for data governance, access control, data security and privacy protection.

Proposed General Data Standards

The proposal of collecting census type data, be it socio economic, housing or financial data from multiple sources brings up the question of the consequences of collecting data that is in different formats and asks questions differently. Each data set uploaded, or data source provided should be graded from 1 being the lowest quality in each category and 5 being the best quality in each category. Proposed standards for this strategy are as follows.

Standard 1: All data sets must include age (not date of birth), gender, race and location for segmentation purposes as a minimum. Possible other information to include would be education level or political ideology.

Standard 2: No ranged data. Financial information in census products includes data sets in ranges. Raw data should be provided with no ranges for the end user to be able to segment properly into whatever data ranges they see fit.

Standard 3: Use the most accurate source of information. Any time a collector of data has a vested interest in keeping accurate records the data is more likely to be accurate. For example, utility companies need to keep accurate records of energy use because they must bill for their services. Data sources that are the most likely to provide the most accurate sources of information should always be used. A rating system for data accuracy will be used to score each data set.

Standard 4. Ask questions in a formatted way. Having a no write in option for any answer will not only standardize the answers and data but it will make aggregating the data quicker and more accurate. Keeping the options down to a minimum amount to answer the question in a useful way helps to bring more value to the data collected.

Standard 5: All data must be raw data without PII. Utility records for example would need to be stripped of the specific address of the subject and only include information pertinent to that data set. Data is segmented at the raw level and then stripped of its personal data to avoid PII at the source of the data set as opposed to at the location of the data. Query level data, as well as summary data could also be used. A rating system for quality of data or flexibility of data could be established.

Standard 6: Reports and analysis must create context rich reports. As an example, the current trend analysis style of government data collections and analysis creates opportunities to present data that is out of context. The annual average wage index, produced by the social security administration has increased in all but one year since 1951 (Social Security Administration, n.d.). Out of context this could be used as a way to portray that annual wages are on the rise throughout the United States for all but one year in the last 65. To provide context for this dollar amount other data points would need to be collected and used alongside this point. These other data points might include: (a) Inflation index to show how much of the increase is simply due to inflation or a normalized table that takes inflation out of the annual comparison; (b) Spending power which would show how much those dollars are worth in comparison to prior periods; and (c) Average increase in different professions, levels of education, geographic zones, age groups etc. To show how much of the annual increase can be allocated to outlier increases in different segments. Perhaps in this scenario Chief Executive Officer, CEO, pay has increased enough to skew the overall data, or annual salary in a specific profession or location.

Proposed Open Source Process

The process for obtaining data for the below examples would be dependent on the agency that the data would be coming from. Using the precedent set by Chetty and Saez (Mervis, 2014) would be how any IRS raw data would be obtained. The same precedent could be used for obtaining social security information. SSN's would not be kept in the final data tables to avoid additional security risk. Data that is already public would be scraped from the public source and entered into a database, for example, property tax information county by county is public information. Some of the proposed data sources do not currently exist in an open and available environment. Categorized banking and credit card information does exist but is likely unshared, proprietary information. The agency that created the actual system for this strategy would be responsible for developing relationships and possibly influencing legislation that would make a full open source system possible

EXAMPLES

Examples of possible data sources and uses of data in social computing.

Smart Utility Meters

According to the United States Energy Information Administration, as of 2017 there are an estimated 78.9 million smart meters installed in the United States (United States Energy Information Administration, 2019). An estimated 88% or 69.9 million of those meters are installed at residential properties (United States Energy Information Administration, 2019). According to the US Census Bureau as of 2017 there were roughly 137 Million housing units in the United States (United States Census Bureau, 2019). Already for residential purposes more than half of the United States households have a smart meter installed at home. Smart meter devices are, according to San Diego Gas & Electric "digital devices that collect energy-use data and – unlike traditional meters – transmit and receive data, too." (SDG&E, 2019). Using a similar technology to cell phone companies for billing an individual phone line, smart meters send data to the utility company that is validated multiple times and ensures that the data is for the home that the smart meter is assigned to (SDG&E, 2019). Because the device is assigned a specific identifier that does not include the details of the people that are living in the home it is a possible fit for secure and accurate data without posing privacy issues as other online methods of census taking or the current form are susceptible to. In addition to a secure platform to count households a simple profile that shows the inhabitants of the household including ages and sex could be associated with each smart device. Even without the profile, energy usage data along with other conditions, it is possible to estimate the amount of people that live in a household. The system would be difficult to manipulate since it is a physical device and would also, as a bonus, answer a few of the ACS questions about electrical usage in a given month and appliances in households, like a modem to indicate broadband internet, without having to ask anyone. While using any social computing network a risk is that the data could be manipulated because of lack of validation efforts on the network side. For example, Facebook does not validate users and a person could have hundreds of Facebook logins which would make using a social media type site much less accurate and susceptible to manipulation. A social computing network of this nature does not have that issue because it is a physical device. It would also be possible for the data on number of households to be validated using public information on property. It should also be noted that since a new network is not being created that no additional data privacy risks would be created by repurposing these smart meters to count the population.

NextDoor App

Nextdoor.com is a social networking site that connections people to their specific neighborhoods, founded in 2011 their mission is to bring neighbors together while protecting their privacy (Nextdoor, 2019). According to the New York Times, NextDoor has set up some 2,000 neighborhoods in the United States each containing roughly 500-750 households each (Stross, 2012). The neighborhoods mostly follow boundaries set up through Maptronics, a supplier of geographic information (Stross, 2012). The network is semi private, does not show up in search engine results and data including member lists are only visible to members within a neighborhood. They do have a form of validation only offering an account to each household limiting the ability of outsiders to manipulate any data within the neighborhood. They either require a credit card validation on a card associated with the address or validation by another neighbor. This is another source that could be used to estimate or while adding profile information count the population without compromising personal data and or adding more information that is already available on county websites for household numbers. A little less secure than using a smart device since some personal data needs to be included in the profile in order to join.

Other Possibilities and Social Networks to be Avoided

Social media networks like Facebook, LinkedIn or other sites that lack a robust validation process should be avoided due to the risk of data manipulation. Data gathered from those sites is of use for population statistics and census style information, it would simply need to be contained to that social platform and should be used in an official government capacity. A Facebook census for example could be used in the same way that both the Obama and Trump presidential campaigns used them. Physical smart devices and closed off networks with strong validation would be the most beneficial data sources to create accurate, secure and actionable intelligence.

Examples of Answering Questions Using Non-Paper Census Data Sources

What is the Average Take Home Pay for the Population of the United States?

Most measures of income including average salaries and average household income concentrate on gross pay, for example the ACS asks about income in its income section and refers to gross income not net. The calculation for this number is much easier to obtain that any other income trend figure. In section 7, we provided an example of three different tax scenarios that started with the same number of household members and the same income and with a simplified tax calculation produced three different take home pay numbers. After adding in credits, other deductions and state and local tax items these take-home pay numbers could be drastically different. That example shows, even with a simplified calculation method, that take-home pay will have a much different outcome than looking at trends in gross pay which is simply the amount of money that a person earns before any taxes, including income tax, social security and local and state tax, are deducted. Take home pay is really the only number that matters. Wages could go up every year by 10% for everyone on average and if it is being outpaced by an increase in deductions from pay or a decrease in credits that a person received the previous year the inference from the data would be very different when looking at take home versus gross pay. This could paint an unrealistic picture of the economy and the populations spending power in any given year or other period. Using a simplified method can hide things that are happening between gross pay and take home pay.

It is important to create content rich actionable intelligence with data projects. Example 1 is an input to Example 2 about poverty. Data segmentation is very important in this data set. The population of the data set is large enough that multiple data segments would be possible without creating groups of data that do not have a large enough sample size to make good data inferences (Deziel, 2017.). According to the IRS, approximately 145,329,000 tax returns where filed during the 2017 filing season for tax year ending 12/31/16 (Internal Revenue Service, 2017). The following data would need to be collected to provide enough information to create actionable intelligence in accordance with this proposed strategy in section 7.1 for population statistical analysis. We propose that, to provide trend data as well as context that at least 50 years of data is taken. Adjustments would need to be made for inflation on an annual basis. Data needed would be as follows; SSN, zip, age, gender race, filing status, gross income, deductions tax due and credits

Changes in take home pay can be assigned to actual changes in gross pay versus take home pay. For example, from one year to the next changes in the tax code could increase or decrease take home pay and produce results that were hidden when only looking at trend data for gross pay. The effectiveness of certain tax credits could be measured as well by looking at the before and after trends of take home pay. The EITC (Earned Income Tax Credit) and child tax credit –created in 1975 and 1997 respectively– would create good breaking points for detailed take home pay analysis (Hungerford and Thiess, 2013.). A measure of effectiveness for a tax credit would be valuable in creating future tax credits or other tax policy.

Example 2: What is Poverty?

Poverty is defined by two widely used formulas: the official poverty measure and the supplemental poverty measure (Short, 2011). The formula does not go into what poverty means beyond the amount a household must make in annual gross income to be “under the poverty line” nor does it adjust fully for pricing differences across the United States in either formula, though the supplemental formula does adjust for some pricing differences in housing. Using this system, the following data would be needed to develop a comprehensive definition of what amount the poverty thresholds should be set at as well as what poverty is, beyond the simple dollar amount. The main features of the actionable intelligence that this data would create is an ability to subset data and rapidly determine poverty levels using multiple different criteria. As well as to make decisions about which anti-poverty programs should have high priority and which ones should not or to design new programs and solutions based on the results. The following chart provides the data that would be needed and a prime source for it along with an alternative.

All data would need to include common population descriptions including, age, gender, race, marital status, education level and geographic tags like county, city of zip code. The preference for geographic tags should be what most closely matches the reality of price differences from one geographic code to the next. For example, there are 43,000 zip codes in the united states (Zip Boundary, n.d.), it is unlikely that zip codes that are right next to each other produce a statistically significant price or wage difference. Conversely, there are 3,141 county or county equivalents in the United States (United States Geological Survey, n.d.) counties are more likely to have a statistically significant difference in prices and wages than zip codes. We suggest that future research determine significant geographic boundaries to base population statistical analysis on, for now the tables include zip code as the geographic tag.

Non-data set related information to create an overall context would need to include proposed budget levels for each item. Definitions for a needed item versus a non-need item for each geographic region must be included. For example, transportation could be considered a need though public versus private would have to be taken into consideration depending on the geographic attributes, New York City where owning a car is not a need versus San Diego, where public transportation is not as robust and a car is a need.

The results could be used to aid in the creation of anti-poverty programs targeted by geographic regions, household sizes, and other population segments. It could also be used to develop personal benchmarks to help the public develop their own personal healthy spending habits as well as answer questions about systematic poverty versus families that are simply living beyond their means. The information could also help determine clearly stated goals for anti-poverty programs and tracking their effectiveness. (a) What are needs per person segmented by geographic location? (b) What is a needs budget for a household of 4 (2 children, 2 adults)? (c) What is the

Table 2. Needed data set's and sources for poverty data example

Data set	Current source of data	Proposed source of data
Take home pay output example 1	N/A	IRS Raw data
Household size	American Community Survey (ACS)	IRS Raw data
Rent/Mortgage	ACS	Mortgage holder raw data
Monthly debt	Census Data	Debt holder raw data
Vehicle expenses	ACS	Categorized bank/Credit card raw data
Gas	ACS	Categorized bank/Credit card raw data
Groceries	Bureau of Labor Statistics BLS (1)	Categorized bank/Credit card raw data
Telecommunications	BLS (1)	Categorized bank/Credit card raw data
Health Insurance	ACS	Categorized bank/Credit card raw data
Medical Expenses	BLS (1)	Insurance company raw data
Property Taxes	BLS (1)	Hospital and bank credit card raw data
Other expenses	BLS (1)	Local public property tax raw data

delta between the needs budget and the current average budget? and (d) Do spending patterns show that part of the problem with poverty is overspending?

CONCLUSION

This study has explored the feasibility and need for radically changing the way the United States census is performed to that of using an *actionable intelligence* approach to generating a data strategy and then using that strategy to identify open sources of data to collect the necessary information for census. The federal government collects data on the population of the United States to fulfill its constitutional requirement to count and analyze the population every ten years in order to determine the number of seats each state has in the U.S. House of Representatives and is also used to distribute billions in federal funds to local communities and other statistical purposes. However, as we show in our paper the current data collection process for census has numerous flaws: it is costly, inaccurate, inefficient, not timely, doesn't allow for collaboration between agencies, and is mostly paper based.

This paper is proposing a new, theory supported, way of collecting census data without deploying the expensive paper-based data collection method that provides unreliable data. The proposed framework starts with the need to identify *actionable intelligence* that should be the purpose of the census data collection, above and beyond the two needs described by the US Constitution (number of seats for each stat in the U.S. House of Representatives, and distribution of federal funds). Acting upon this actionable intelligence, the new framework is based on six goals and six standards of combining already existing data sources that are not only less costly, accurate, efficient, timely, allows for better collaboration between different agencies, and automatic, but also takes into account the data privacy necessary to protect PII of the population of the U.S. We are aware that this may not be the only possible approach to automate U.S. census data collection. Thus, our goal is not to propose the only possible solution but rather to start the discussion on making radical changes rather than a 'band aid' approach. This study does not go into the absolute effectiveness of possible data that will be collected, it is simply a proposal for a strategy that can offer more agility, transparency and actionable intelligence for decision making to be used on by many different groups.

This study is limited to the role of the federal government in data collection activities and designing a strategy that can be used for other groups as well. An open source system for government data collections means that it will be more accessible and not fall under the direct management of the federal government though it will be able to be accessed by agencies within the government. The study is also limited to two specific government agencies the IRS and the US Census Bureau in analyzing what information is currently collected, their methods and purpose of the data that is collected. Many other departments of the federal government collect data on the US population and publishes multiple reports ranging from weekly reports to reports published every ten years, like the census short form results. Other major agencies that participate in data collections include the Department of labor, agriculture, education and energy.

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KEY TERMS AND DEFINITIONS

Actionable Intelligence: the specific knowledge, information, data, big data, needed to make a specific decision. (Jennex)

Census: the process of collecting data on a population for the purpose of counting and analyzing that population.

Data Privacy: the protection of any representation of information that permits the identity of an individual to whom the information applies to be reasonably inferred by either direct or indirect means.

KM Strategy: the construct that identifies KM goals, strategic alignment, metrics, and knowledge sharing/use incentives for a KM initiative/project. (Jennex)

Knowledge Management: The Practice of selectively applying knowledge from previous experiences of decision making to current and future decision making activities with the express purpose of improving the organization's effectiveness (Jennex)

Social computing: as an umbrella term for research and development at the intersection of computer science and social science (Manovich)

Chapter 12
The Project Manager as the Driver of Organizational Knowledge Creation

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ABSTRACT

The areas Project Management and Knowledge Management include studies on the project and project team levels, but a specific focus on the role of the Project Manager in managing knowledge within the team has received less focus. The authors show how knowledge is created within the project team environment, and the specific role of the Project Manager as an individual uniquely situated to drive the creation of knowledge in the environment by facilitating, directing, and controlling team activities through the four SECI model phases. Using a single case study approach, this research shows how the PM acts as a "mixing valve" in the flow of knowledge in a dynamic, multi-directional, process within the project team environment.

DOI: 10.4018/978-1-7998-2355-1.ch012

INTRODUCTION

In today's knowledge rich business environments, competitive advantages are gained and maintained through efficient knowledge management; whether creating new knowledge or sharing existing knowledge throughout the organization. Research in the field of Knowledge Management and organization learning includes topics such as explicit and tacit knowledge (Kogut and Zander 1992, Von Krogh 1998, Nonaka and Von Krogh 2009), managing knowledge assets (Despres and Chauvel 1999, Eppler and Sukowski 2000, Baskerville and Dulipovici 2006, Goel, Rana et al. 2010), and organizational knowledge creation (Von Krogh 1998, Nonaka, Toyama et al. 2000). In the field of Project Management, practitioners and researchers have emphasized the importance of well-structured and managed projects for overall organizational success. For instance, researchers have studied knowledge and knowledge management at the project and team level (Bresnen, Edelman, Newell, Scarbrough, & Swan, 2003; Ajmal &Koskinen, 20008; Hanisch, Lindner, Mueller, & Wald, 2009; Hargadon, 1998a, 2013; Todorović, Toljaga-Nikolic, & Mitrović, 2016) and managing knowledge enablers and project success (McKey & Ellis, 2015). The exploration the role of PM in organization knowledge creation has not been as well addressed, despite the crucial role the PM plays.

This this research explores knowledge creation (an aspect of knowledge sharing) within the project team environment and the role of the PM in the process. Authors illustrate the PM's role in facilitating and leading project team members to develop both ends of the knowledge continuum for themselves, their team, and the organization. This research shows how PM's interact with the project team to facilitate the creation and sharing of new knowledge. This research contributes to the current KM literature by building and refining a conceptual model that displays the knowledge creation process as an infinite loop, rather than a linear process. Managerial implications are also discussed.

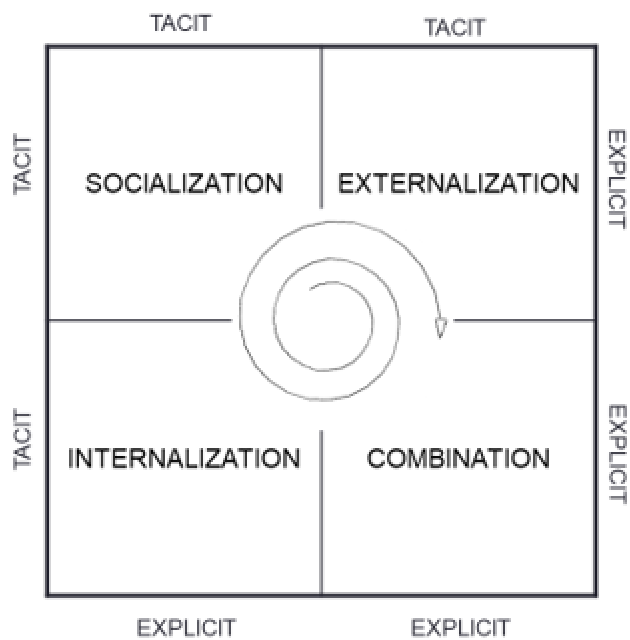
Organizational Knowledge Creation

Knowledge is more than a static asset; it is itself dynamic, and changing (Spender 1998, Nonaka, Toyama et al. 2000). Nor is it decreased when shared. With each sharing it is enhanced and changed as it is combined with the current knowledge of the receiver. The sharer retains the shared, and subsequently receives new knowledge to add to his current knowledge, thus continuing the creation process. As Spender (1998) points out, we do not possess certain knowledge, but rather are bound by the learning processes. This process is unique to the individual as he/she gains experience. Developing, gaining, or acquiring new knowledge, understanding and internalizing it, and then dispensing it throughout an organization is considerably more beneficial to the organization than limiting itself to narrow and fragmented foci associated with short learning horizons and limited learning capabilities (Tallman and Yip 2010).

According to Nonaka and his colleagues, knowledge is converted through a defined process (Nonaka 1994, Nonaka, Toyama et al. 2000, Nonaka, Toyama et al. 2000, Nonaka, Toyama et al. 2008, Nonaka and Von Krogh 2009). The SECI model describes a process through which our experiences are converted into knowledge; 1) Socialization (S), where tacit knowledge is shared and combined with other tacit knowledge; 2) Externalization (E), where tacit knowledge is made explicit; 3) Combination (C), where explicit knowledge is combined with other explicit knowledge; and 4) Internalization (I), where explicit knowledge is made tacit (Figure 1).

The model, however, is focused on the individual and how we create knowledge through our interactions with others. In the project environment, individuals work together, and the team becomes the entity gaining new knowledge. Additionally, Nonaka et al. 's (1994, 2000, 2008, 2009) conceptualization of knowledge creation implies that we move through the creation steps as individuals without any specific guidance. While guides such as mentors and Knowledge Brokers have been discussed in the literature (Nonaka 1994, Hargadon 1998, Hargadon 1998, Hargadon and

Figure 1. SECI model



Sutton 2000, Burnett, Brookes-Rooney et al. 2002, Jones, Herschel et al. 2003, Lomas 2007), they are not described as purposeful facilitators to knowledge creation, but rather as passive in nature. A challenging part of the process stems in the tacit nature, its ties to a particular context (Buchel 2007), and the importance of someone responsible for managing its flow through the team environment. Our research shows the PM assumes the mantle of responsibility to decisively facilitate knowledge creation in the team.

Methodology

Case study methodology was chosen to explore the PM's role in knowledge sharing and creation. The context of this research was a Pharmaceuticals company ("PharmCo") that develops and markets patent-protected prescription drugs. PharmCo offered a fruitful environment to explore and study project management practices due its highly structured Project Management structure. There were more than 130 projects in various stages of development at the time of this research and based on the interviews with four PMs and two executives, one project was identified for this research. All project-specific data were collected (observations, team member interviews, archival data) from a single project.

The research participants consisted of four Project Managers, five project team members, and two executives responsible for project oversight. The key contact also identified the main PM (PM1) and her team, as the most overall representative of the projects undertaken. Likewise, PM1 identified available Project Team Members (PTM) for participation.

Data Collection

Data was collected during a three-month period and consisted of three types of data: 1) personal, face-to-face interviews (Table 1), 2) direct observation of project meetings (Table 2), and 3) archival data (Table 3), which provides opportunities for methodological triangulation (Denzin 1970). Two initial interviews were conducted via phone due to participants' schedule, others were conducted face-to-face on the PharmaCo's campus. Personal interviews followed a semi-structured style, which provided both boundaries and flexibility to the interview process (Myers 2009). Both initial and follow-up interviews were recorded and transcribed. Follow-up interviews topics were based on the observed meetings or information provided through previous interviews. '\

Information gathered through observation provided another view to knowledge creation in the project team (Yin 2009). Four, 90-minute weekly Launch Management Team (LMT) meetings were observed providing 360 minutes of observed time,

Table 1. Interview statistics

Data Collection Type	Source	Quantity	Length (min.)	
			Total	Average
Initial Interviews	Project Managers	4	201.3	50.3
	Project Team Members	5	251.1	50.2
	Executives	2	60.3	30.1
	Sub-Total	11	514.6	46.8
Follow-up Interviews	Project Managers	11	132.5	12.0
	Total	22	647.1	29.4

Table 2. Observation data

Data Collection Type	Source	Quantity	Length
Meeting Observations	Weekly Team Meeting	4	90 (min.)
	Total	4	360 (min.)
Archival	Team Meeting PowerPoint Slide Deck	4	28 – 67 pages
	Emails	10	N/A
	Documents	3	N/A

exclusive of pre- and post- meeting observations (Table 2). The LMT was the best representation of team interaction and provided the most efficient means to observe both PM and team members in a social setting.

The review of archival data provided a third means of comparison and established an objective view of PM practices used in the project. Slide decks were a primary means of both presenting information and combining information from various work areas. Four decks were collected and analyzed, which ranged in length from 28 to 67 pages. Additionally, ten emails representing pre- and post- meeting communications, and three other documents were collected.

Data Analysis

A total of 43 distinct data sources were reviewed and coded: 22 interviews, ten emails, three observation notes, and eight slide decks. All interviews were transcribed and coded by the lead researcher. To ensure coding accuracy, a non-participant colleague also coded one interview. There was an overall average agreement of 88.73% on coding, and a Cohen's Kappa Coefficient score was .43, which shows a fair to good agreement (Cohen 1960, Rigby 2000).[1]

Miles and Huberman's (1999) discussion of qualitative data analysis breaks the process down into three main areas; 1) Data Reduction: "the process of selecting, focusing, simplifying, abstracting, and transforming the data that appear in written field notes or transcriptions.", 2) Data Display: "an organized, compressed assembly of information that permits conclusion drawing and action", and 3) Conclusion Drawing and Verification: "beginning to decide what things mean…" and "the meaning emerging from the data have to be tested for their…validity". Using the guidelines from Miles & Huberman (1999), the researcher coded all data using the QSR NVivo 10 qualitative analysis software.

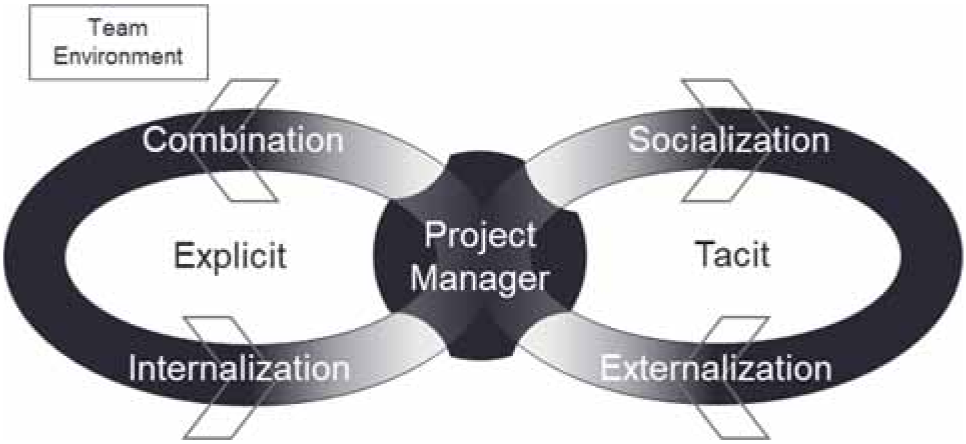
Results and Discussion

Before we can envision a new role for project managers, we must first understand how the current role is perceived. Most of the literature concerning project management, whether referring to the PM or the team, focuses on helping project managers complete tasks and projects successfully. This then steers their thought process so they are focused on completing the tasks required to meet the stated objectives in order to be successful; not on creating or facilitating greater team or organizational knowledge.

This research explores knowledge creation in the project environment. Knowledge within the project team flows from individual to individual; from individual to group; and from group to individual (Alin, Taylor et al. 2011); but unlike the flow of knowledge experienced independently, this process is actively directed and facilitated by the PM in a project team (Bibbes, Rollins et al. 2012, Bibbes, Rollins et al. 2017). Nonaka's (1994, 2008) model describes a sequential process of knowledge created in each stage, but along a defined path (Nonaka 1994, Nonaka, Toyama et al. 2008). The research shows a more dynamic knowledge creation process happens in the team environment (see: Figure 2).

Here the PM acts as a "mixing valve" (a device that acts to facilitate, regulate, and control the flow of water through a system) within a project team's knowledge creation process. To facilitate the flow of knowledge in the organization and the project team, some sort of controlling action is needed. One team member describes this as follows:

Figure 2. KC in the Team Environment



She's (PM) storing our knowledge and experiences within our LMT; "oh, heard about blah-blah-blah from the work-stream in another brand, PM can you check?" And she would reach out to other project managers or the work-stream and get the information and share with the brand team and later with the entire LMT. She is very connected to the entire company.

Next, the SECI model (Nonaka, 1994) is described in the project environment.

Socialization

Socialization, where tacit knowledge is shared and combined with other tacit knowledge, occurs within the team environment in three distinct ways, 1) group in the form of weekly team meetings; 2) individuals in the form of one-on-one meetings between the PM and team members; and 3) direct interactions between team members. Weekly project team meetings are the main social setting initiated and overseen by the PM, while one-on-one meetings, often initiated and controlled by the PM provide for a more intimate experience. Like one-on-one meetings with the PM, direct interaction between team members is also a more personal knowledge creation activity. While this activity does not directly involve the PM, but the PM's actions do influence their occurrence, timing, significance.

A recognized key element for team success is that of cohesiveness. In a well-formed team, the lines of communication are open and the flow of knowledge between people occurs easily. The PM, as the team leader, directly affects this flow. In describing team creation PM1 says:

Once you can get that dynamic down, in the sense that "ok, do I have all the right people," and that probably takes a couple of weeks. Then what I did was open it up "this is what the LMT is all about" and made the statement "anything you want to talk about, let's talk about it here, but we have to keep it to a minimum. … this is the place where you are going to have everybody together and this is the place where you want to bring those topics that you feel are relevant to the whole team.

Without the PM, the creation of a place where socialization can take root and flourish would be left to the individuals. Absent of the PM, levels of trust between individuals must be created ad hoc. The PM is a surrogate for this process and creates trust collectively by first establishing trust between him/her and the team. This is then extended among team members through team and individual meetings.

During the period of formal meeting procedures, tacit knowledge sharing occurs. The PM sets the stage and guides the team through the meeting agenda during which attendees hear and absorb others' experiences.

A more intimate form of socialization is seen in the one-on-one meetings. These are used by the PM to keep abreast of project activities and progress, gain insights into issues or problems, and plan for upcoming group meetings. While they are often planned, one-on-one meetings can occur at any time, as PM4 describes:

The interactions could literally be on the elevator. Sometimes I'm getting three status updates as I'm getting my food in the cafeteria."

Whether it's physical or virtual presence, formal or informal interaction, the PM is at the center of these interactions. Without these interactions, either in group or individual settings, the sharing of knowledge becomes more difficult. The PM, as the driving force establishes the place for socialization activities by creating a safe haven for team members to come and share their experiences; a place where they can express their knowledge.

Externalization

In the project team environment, the externalization, where tacit knowledge is made explicit, occurs through various means from the creation of the project charter, to weekly status reports, to capturing final lessons learned. Each of these common project documents articulates team knowledge and sharing them disseminates it within the team. A function therefore of the PM, it is to not only create and share their own knowledge in this way but ensure team knowledge is captured and shared as well.

The project charter is the first form of the teams' externalization of knowledge. The document captures specific information about project goals and objectives, team members, stakeholders, and scope. Each of these pieces of information reside within others. Finding and articulating it in a format to be shared with others, is one of the first actions of the PM. PM1 describes how she undertakes this endeavor:

I first showed her the Charter and sat down and talked about the Charter. … Who are our stakeholders, and then I went through some key milestones … I gave her an overview and gave her the lay of the land. What the company expectation is, in the sense of the various high-level steps in order to have a successful product launch.

Externalization continues as an important aspect of the team environment because individual knowledge often results in communications such as Weekly Status Reports or Updates. By articulating the activities, action, and accomplishments of their area of focus, PTMs not only externalize their tacit knowledge of the topic, but it is shared with others who then see it, read it, and incorporate it with their own tacit knowledge. PTM1 provided insight into this action:

…it helps me to have a more holistic view outside my microcosm, what it takes to bring a product to market in this case; … to be broadening my own knowledge of the overall process. (PTM1)

The most notable vehicle for capturing project tacit knowledge is the practice of creating "Lessons Learned" documents. These documents capture what did or didn't work, and why. Lessons Learned documentation is the most prevalent methodological attempt at turning tacit team knowledge into explicit organizational knowledge. Not only does it codify different aspects of knowledge created, it's also a key source by which knowledge is shared. When completed, knowledge is archived and later available so the organization can learn from past mistakes and triumphs. PM3 expressed the value of these documents when he said:

The outcomes of the post-mortems are logged, captured, and tied to the project. When I first came here that is the first thing I asked for, a "lessons learned," … [I do that] Because maybe what you see in projects that you are going through and looking at projects, and looking at the life cycle of the project going forward sometimes there are things hidden that you don't see that come out in the post mortem- kind of like the "I got you" that you don't want to repeat.

Without the influencing factor of the PM, externalized team knowledge would require additional contextualization steps by PTMs. These steps are circumvented by the PM due to his overall knowledge of the team, its goals and objectives, and who needs what information. His unique position within the team environment allows the PM to provide the proper context and facilitate the externalization process within the team.

Combination

Combination, where explicit knowledge is combined with other explicit knowledge, was most prevalently seen in the form of the weekly presentation referred to as the "LMT deck." We also see Combination in the form of emails wherein the email author externalizes some knowledge, then combines it with some other form of externalized knowledge such as PowerPoint slide attachment.

Table 3. LMT deck data

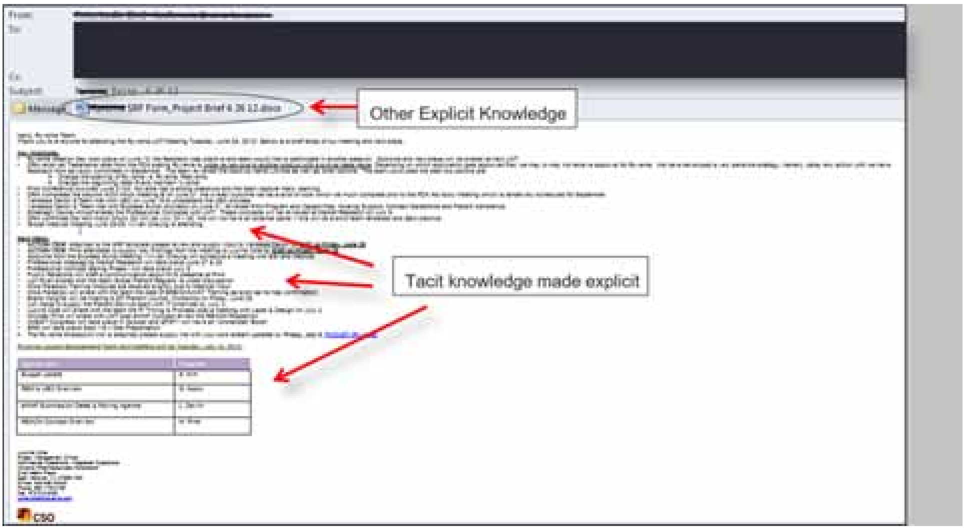
LMT Deck Sections	Description
Introduction and Agenda	The PM outlines each week's discussion topics and any relevant and important pieces of information or announcements
Current Week's Discussion Topics	The knowledge content for this section changes from week to week, and is often comprised of several different PowerPoint slide decks developed and submitted by team members. These slide decks are expressions of the explicit knowledge of the team created by different team members and combined into a single expression of explicit knowledge by the PM. It is the PM's responsibility, and through their direct action that this knowledge is collected and combined into this single source
Workstream Updates	This section contains the externalization of each workgroup's knowledge in the form of their weekly status reports, which are updated and added to the overall combined knowledge each week. While the format used in this section is common and constant for each team and each week, the knowledge content is not. The weekly updates help ensure new knowledge is available for access from this single
Core Project Information	This section seldom (if at all) changes during the course of the project. This section makes up the beginning template for the Weekly LMT slide deck, and is a common format across various projects in the greater organization. Within this section is the core project team knowledge, the structure of the team, the team members, the Project Charter, where to store and how to access team documents (knowledge), etc. In this way, the combined explicit knowledge captured is more easily imported from, or exported to, other teams and other areas.

The LMT deck was the main source and vehicle of knowledge retention, sharing and management. Table 3 summarizes the information in the LMT deck. In the sense that it is used to retain team knowledge, the deck originates with the PM. The deck itself is distributed via email, and past and present copies are kept within designated folders on the projects SharePoint site. In this manner, the combined knowledge of the LMT deck is further combined with other explicit knowledge in the form of previous LMT decks, and other explicit knowledge kept on the website or distributed via email.

But knowledge is not only combined and shared through the LMT deck, the externalized explicit knowledge is combined and shared through emails. A common form is the weekly meeting recap email (Figure 3). In this email, we see how the actions and discussions are written and communicated. Included with this sample is as an attachment which it is also a form of explicit knowledge and adds to the combination of the knowledge created.

The PM is the conduit for the Combination of knowledge. As articulated, codified knowledge is given to the PM; she combines it with others' knowledge provided

Figure 3. Sample email



to create a single space from which team members can access the new knowledge. These actions are channeled through and driven by the PM.

Internalization

The nature of the Internalization process, taking the explicit and turning it into tacit, does not lend itself to overt and demonstrable displays. However, through observation of actions, and discussions with team members, it can be shown how and when this process occurs. Knowledge is internalized through the review of documents in preparation for meetings or at the start of the project. Documents such as the Project Charter, recap or meeting invitation emails, along with slides developed during the project, and "lessons learned" documents, are examples of sources for internalized knowledge. PTM1 shared the following in this regard:

When we are asked to prepare a new LRR for a different project, people are sending us previous ones, so we are trying to use some tribal knowledge from previously executed things.

In this statement the term "tribal knowledge" is a synonym for tacit organizational knowledge, the knowledge held by individuals throughout the organization. We can assume the knowledge gained from the team, through other process steps, is combined with their own tacit knowledge; and it is in the Internalization process that this occurs. The weekly team meeting is a fertile ground for the internalization process. During the observed meetings, the "side-bar" conversation was a common activity. In these conversations, team members reinforce their understanding of information provided by asking clarifying questions. PTM5 described the importance of the weekly meeting as follows:

"LMT is the forum where they find out what else is happening; how does it fit with my part and what am I doing; how does my part fit in; how does somebody else's part fit in; are we making progress? That is a very important objective of LMT."

As knowledge is directed through and by the PM, he/she must also ensure it is accepted and internalized by the team. As a team member receives information, they must internalize it themselves; the PM contextualizes the knowledge so it can be more readily accepted. We see how they actively seek to ensure team members are positioned to understand aspects of the knowledge being channeled their way, in these comments from PM1:

We will have discussions in the meetings as it affects people…I start with an introduction, then say, 'let me show you what other brands have done. Some pain points, some positives and*…I suggest the Work Stream lead meet with the Brand Lead, so [they] can get an understanding of how it is interconnected …*

The PMs actions directly aid the Internalization process. They position the topic for internalization by guiding and facilitating discussion along a common path. Through this action, the PM can mitigate surprises and misunderstanding.

Importing Knowledge

As the main control mechanism of knowledge within the team environment, the PM also influences and controls what knowledge is brought in from other areas. With their overall view and knowledge of the team, the PM is able bridge the gap between team members and provide a conduit for mixing seemingly disparate sources of knowledge. In PMT4 words:

I think the PM oversees that whole process, and if she hears something in a conversation, she's always very good about following up to make sure we all do that. She always has her ears perked for "oh, great you've got this." And I think she has a good understanding of the different functions.

In their preparations, PM's search for, and bring to the team, other pieces of knowledge from outside sources. Regarding her preparations PM2 shared:

If I start a project I haven't work on before I would go to the intranet or I would go to the PMO SharePoint and I would look for the documents for the same type of project.

Because of their involvement in other projects, the PMs can import knowledge created from previous projects. PM4 comments on this:

A couple of things I learned from my last project, when we came to that stage here doing the same things, I reached out to my brand lead and said 'hey- heads up;

this is what we did in my previous project, and these were some of the pitfalls, these are some of the things we learned, I would advise not to do that in this situation; we are facing the same circumstances, so let's keep in mind the experience from another project." Or this we did on another project that helped us at this point, how about looking into that here.

We can see how the PM's involvement in other areas positions them to seed new teams with knowledge from these other areas. Without importing knowledge, the knowledge created in other areas would not be used, and new teams would be forced to start from scratch in their knowledge creation, most likely reinventing the wheel as they do so.

Exporting Knowledge

The PM also has a strong influence on the knowledge that is exported out of the team, as well. Through the externalization and combination of project knowledge, the PM creates a means for the knowledge created within the team to be exported out. But not all knowledge that is created within the team is available for or should be exported. As the valve for the team, the PM also controls not only what, but if knowledge can be exported. Issues such as regulations or confidentiality are among some of the things that may influence what, or when, the PM allows knowledge to be exported. PM4 shared:

There are times when I may know something about the project that I am working on that I am not supposed to share with other people. If it is something that may hurt rather than help the company; you don't want things leaking out also, so you want to keep it confined to specific people until things are sure or certain. That is one area where I would withhold information. Where it would do more damage than good. Other than that, I'm sharing it.

In each of the above areas, Socialization, Externalization, Combination, Internalization, and the importing and exporting of knowledge, the actions are driven and controlled through the PM. Through their efforts the team benefits by receiving regular feeds of information to aid in the overall knowledge creation process. In the team environment, it does not matter the direction of flow. The PM contextualizes and directs the knowledge dynamically and not necessarily in the sequential flow of the SECI model as discussed by Nonaka. This is how the knowledge creation activities on the team level differ from knowledge creation on the individual level. It is also why the Project Manager, as the leader of the project team, is vital and uniquely positioned to ensure that as knowledge is created, it is directed to the right area or person. A team without a PM is more likely to experience "skewed effects" resulting in muddled scope consensus, as expressed by one PM.

SUMMARY

Finding competitive advantages in business is a hard fought and constant struggle. The search for insight in gaining advantages is evident in the wealth and growth of the literature aimed at helping management in this regard. This research spanned the scope of knowledge creation and project management and explored the actions of Project Manager in managing team activities. The process model of Socialization, Externalization, Combination, and Internalization (SECI) was reviewed in accordance to its relationship to the tacit and explicit knowledge continuum, and how the PM is uniquely positioned to facilitate and drive the process of creating knowledge within the project team environment.

The research outlines the actions and activities performed by Project Managers in relation to the SECI model processes. When combined with a linear view of the tacit-explicit knowledge continuum (Nonaka and Von Krogh 2009) we can envision an infinite loop path so that knowledge is continuously being created. Positioned at the center of the loop where the two sides (tacit and explicit) cross, we place the Project Manager. In this position, the PM acts as a mixing valve that influences, controls, and facilitates the mixing of explicit and tacit knowledge, and directs it to the required knowledge creation process.

A key finding from this research is a more dynamic and non-sequential process for project teams. The creation of knowledge in the team environment occurs between any two aspects of this model. Knowledge is created along Socialization-Combination path, by-passing Externalization and Internalization, when facilitated and driven through the valve that is the Project Manager. The efforts of the PM also create knowledge along the Externalization-Internalization path without necessarily passing through Socialization or Combination.

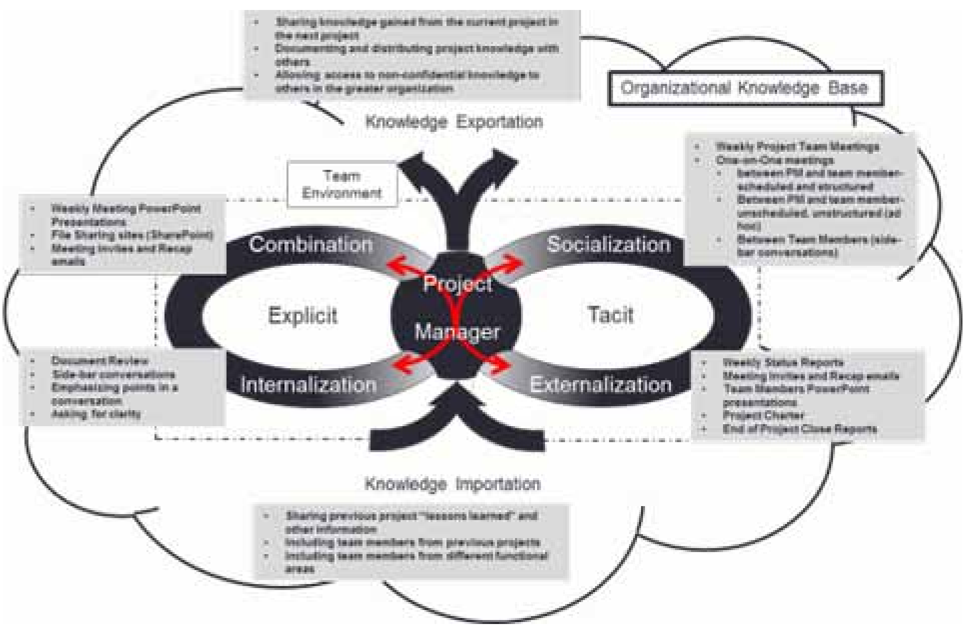
This is in part due to the nature of the team environment. In the project team environment, the individual's efforts are enhanced when paired with other team members. This creates simultaneous pathways of interactions and directions in which knowledge creation flows may proceed. In this way multiple people are creating knowledge at any point in the loop, and the team as a unit is creating team knowledge dynamically with no single direction of process phase steps.

PMs facilitate the Socialization process by organizing and directing team and one-on-one meetings with project team members (PM-to-PTM, and PTM-to-PTM), and by doing so create an environment in which the sharing of tacit knowledge between team members is focused for the benefit of the team. The Externalization of knowledge is facilitated by the PM in the form of written weekly status reports and their presentation, and project close out reports. Through these activities, the PM draws out the tacit knowledge from team members and influences the articulation of knowledge into an explicit form. The explicit knowledge drawn out is further developed in the Combination process. Tools such as weekly MS PowerPoint slide decks, which contain various status reports, bring together the explicit knowledge previously captured. Additionally, the use of document storage and management software such as SharePoint provides a space for the combination of various knowledge elements. Finally, the PM helps with the Internalization of explicit knowledge by providing context of the various forms of shared knowledge. The context provided aids PTMs in their process of converting the acquired explicit knowledge into their own tacit knowledge.

The PM also facilitates the flow of team knowledge by directing its inflow and outflow. As the recognized leader of the project team and coupled with their broader interaction with the larger organization, the PM filters and directs knowledge both into and out of the team environment. By filtering imported knowledge, the PM can control the amount and context of the knowledge so that it is of value to the team. By controlling the exportation, the PM protects the team and the larger organization from untimely, and possible harmful knowledge leaks.

The original SECI model (2008) is focused on the individual and how we create knowledge through our interactions with others. In the project team environment, the individual's efforts are enhanced when paired with other team members. This creates simultaneous pathways of interactions and directions in which knowledge creation

Figure 4. Complete model



flows may proceed. In this way, multiple team members are creating knowledge at any point in the loop, and the team as a unit is creating team knowledge dynamically with no single direction of process phase steps.

CONCLUSION

This research illustrates the role of the PM in the knowledge creation process in a project team environment. The findings suggest that knowledge creation processes and actions are driven and facilitated by, and through, the PM in project environment. Through his/her efforts, teams benefit by receiving regular feeds of information to aid in the overall team knowledge creation process. In addition, in a project team environment, the direction of knowledge flow does not seem to matter. The findings suggest the PM contextualizes and directs the knowledge as needed, but not necessarily in the sequential flow described by Nonaka et al. (2008). This is how the knowledge creation activities on the team level differ from knowledge creation on the individual level.

Contribution and Managerial Implications

Exploring knowledge creation in the project team environment contributes to both theory and practice. From the theoretical perspective, combining Knowledge Management and Project Management fields brings new insights and opens new research areas. This research also contributes to theory development by directly applying it to specific actions and persons. By viewing the role of the PM as a facilitator and driver of knowledge creation, a new stream of research can be undertaken to more fully understand the interactions of the PM, the project team and other stakeholders. From a practitioner's perspective, a new understanding of the role of the PM in the creation of knowledge can refine the actions and practices employed in managing projects and creation new knowledge.

The role of the PM is viewed and understood to be one centered on action; getting things done; meeting objectives within defined timeframes and under specific constraints. By developing a new understanding of the PM as a 'mixing valve' in the flow of knowledge, this research provides project management practitioners, and in a broader sense managers in all areas of an organization, new ways of conceptualizing their work with peers, subordinates, and superiors. By understanding their role as one more focused on facilitating and driving the creation of knowledge, Project Managers can focus on enhancing the paths and tools of knowledge capture, that until now have been, at best, underutilized.

By focusing on the knowledge creation process, the steps within that process are highlighted, as are the tools and means by which step completion is achieved. Active, purposeful, knowledge creation through the Socialization process means direct involvement by Project Managers. Project meetings (group or individual) are not solely focused on the task completion percentage, but structured so all team members are provided an opportunity to expand the knowledge base. Active, purposeful, Project Managers seek to ensure they match team members together, even though the match may be counter intuitive. They seek to enhance the interpersonal interactions of the team. Face-to-face meetings are elevated and enhanced so their agendas and purpose include the promotion a knowledge creation. This means interaction and involvement of all team members beyond just reporting accomplishment. Time is accommodated before or after meetings to allow for sidebar/off agenda discussions among team members. Meeting agendas are developed to include team members in the discussion, while the PM actively establishes and drives the context for understanding.

When PM's understand the importance of their role in the knowledge creation process, externalization tools are positioned so all team members understand their importance in gaining knowledge. They are shared and discussed. Their combination with other externalized knowledge is purposeful and made accessible. Further, PM's are concerned with team members understanding the content and the application of the knowledge to their roles within the team. They seek to ensure understanding, and extract that understanding so it is shared with the team.

In this respect, and from this viewpoint, every project is a knowledge creation opportunity, and as such, the Project Manager is a "Knowledge Creation Leader." The team itself is not just a team, but a resource in the knowledge management arsenal, on par with file cabinets and databases. Knowledge Creation Leaders would then be measured on the effectiveness and efficiency of the knowledge created and the process used. Project success is measured not only by achieving time, cost, and quality goals, but also knowledge goals.

Highlighting the Project Manager as a facilitator, controller, and driver of team knowledge also changes how we train new Project Managers. We must still meet the bottom-line objectives, the project constraints, but in order to meet the new knowledge requirement, PMs must be adept at managing the different aspects of knowledge creation. For example; meeting organization and effectiveness is not merely important as a time management issue, it also becomes important in achieving the correct place for socialization and the exchange of ideas. Proper meeting content becomes more important in order to establish the correct context for knowledge creation.

LIMITATIONS AND FUTURE RESEARCH

This research was a single-case research, which can be viewed both as strength and limitation. Data for this research was collected within a single organization, whose structure and practice of project management aided in the research design and data gathering process. While the company was well suited for this research and case study research provides rich context to explore new concepts from which to draw conclusions, it lacks generalizability (Eisenhardt and Graebner 2007, Myers 2009, Yin 2009).

There are several avenues for future research in Knowledge Management in project environments. One of the topics is the characteristics of the PM and how they may affect his/her knowledge sharing and creation. For instance, future research could explore if there are differences between male and female PM's way of facilitating and driving knowledge creation. In addition, future research could examine what is the effect of experience or the level of education of PM and leadership style on her/his knowledge creation activities.

This research was conducted within one organization and focused on one project in a highly formalized project management environment. Future research could explore knowledge creation and the PM's role in the organization with less formalized project management practices. The environment that project team functions could be a factor regarding how a PM drives and facilitates knowledge creation. For instance, some of the team members in this research attended meetings virtually. The question for future research could be how virtual project teams manage their knowledge creation process.

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ENDNOTE

1 The kappa coefficient provides a score of inter-rater agreement and is an indication of the degree to which separate observers agree above what would be expected by chance. While the achieved Kappa score of .43 is within the accepted range of fair agreement, the researcher recognizes it to be at the low end.

Chapter 13
An Agricultural Knowledge Management System for Ethiopia

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ABSTRACT

Agricultural KMS development involves various participants from different communities of practice (CoPs) who possess their own knowledge. However, the current development of technology neglected the local communities who possess indigenous knowledge, which is the key success factor for agricultural development. This chapter discusses how to integrate scientific and IK in agricultural KMS development and use. An interpretive analysis of primary qualitative data acquired through in-depth, semi-structured interviews and participant observations was carried out following system development action research approach. The research result yields concepts for understanding the process conceptual framework in KMS development and use for knowledge sharing and integration.

DOI: 10.4018/978-1-7998-2355-1.ch013

INTRODUCTION

Literature is rich with the potential of ICTs as enabler for sustainable socio-economic development (Puri, 2007). The applied technological advancements and developed tools are potentially capable of supporting the agricultural sector and smallholder farmers (Masinde, 2013). However, their use and relevance are still alien to the local rural communities (Masinde, 2013). Agricultural knowledge management systems are, therefore, unsuccessful to provide the full promised potential of ICTs in developing countries (Puri, 2007; Masinde, 2013). Knowledge has also been recently receiving much attention as the basic enabler for the sustainable development and innovation (Sarkhel, 2016). Consequently, the notion of knowledge creation, capturing, and sharing has been repetitively raised by research and development organizations in their efforts to transform the Ethiopian and other developing countries agricultural sector. However, most of the current knowledge management (KM) and KMS development approaches focuses only on scientific knowledge, while overlooking the roles of indigenous knowledge (IK) contained by local communities.

The weak linkages between the scientific and indigenous knowledge are compounded by the historically marginalization of IK from the modern scientific community (World Bank, 2005; UNDP, 2012). Such approaches, thus, correspond and respond poorly to farmers' needs and expectations (UNDP, 2012). Hence, it is arguable that following such approaches of knowledge trend can led to solutions that do not fit the realities in the content. This circumstance has led to growing interest in the importance of IK and incorporation of it with scientific knowledge in KMS development and use in order to fit IT systems to users' needs (Puri, 2007; Masinde, 2013).

It is generally accepted that IK plays a crucial role in the developing countries agricultural production systems. However, IK is no longer reliable on its own which necessitates its integration with scientific knowledge and techniques for the enhancement of the agricultural sector (Masinde, 2013; Songok et al., 2011). In agricultural KMS development, integration of indigenous knowledge with scientific knowledge is a critical success factor (Puri, 2007; Masinde, 2013). This research, thus, focuses on understanding the sharing and construction of integrated diversity of knowledge as their integration would achieve more than either in their separation, whereby the full promised potential of ICTs in agricultural KMS development can be provided. Despite the fact that the integration of scientific and IK can be expected to improve agricultural productivity, yet there is no clearly developed framework demonstrating how the two can be integrated in a KMS development process. Thus, the study aims at contributing in the discourse on how to best integrate scientific and IK in agricultural KMS development and use. Besides to the theoretical understanding, this research also addresses the design tasks faced by practitioners. The solution of the real problem must be developed and evaluated the use of it using the appropriate criteria within socio-technical design science (Miah et al., 2012; Jennex and Olfman, 2001). Accordingly, this research in action further seeks the understanding of the KMS development and use in order to create the appropriate technological artifact for supporting the knowledge sharing and integration in agriculture. The present research is, therefore, driven by the following main research question:

How can the indigenous knowledge be best integrated with the mainstream of scientific knowledge in agricultural KMS development and use?

LITERATURE REVIEW

Davenport and Prusak (1998, page 5) defined knowledge as "*an evolving mix of framed experience, values, contextual information and expert insight that provides a framework for evaluating and incorporating new experiences and information*". Knowledge is a crucial organizational asset but often it is a resource difficult to access that is challenging to share, imitate, buy, sell, store, or evaluate (Jennex, 2009). This is due to organization's knowledge is mainly embedded in the minds of its members, working routines and processes, organizational rules, practices, and norms (Jennex, 2014; Dalkir, 2005). Jennex (2009) stated that, in order to make knowledge repository useful, it must capture and store the context. It is, hence, crucial to understand knowledge with its context to facilitate the knowledge capturing from its source in agricultural development and making it available for reuse.

Knowledge created and used in agricultural sector falls into two categories: scientific and indigenous knowledge. Scientific knowledge includes all methods and practices driven by theoretical models and governed by testing of hypotheses and experimentation (Tripathi and Bhattarya, 2004). While IK is the knowledge and experience applied by local people passed over generations through trial and error locally with long histories of close interaction with the natural environment across cultures and geographical spaces (World Bank, 2005; Lanzano, 2013). It has long been used as the basis for local-level decision making in agriculture, art and craft, communication and entertainment, traditional medicines and healing, education, and other vital socio-economic activities in many parts of the world (Sarkhel, 2016; Lanzano, 2013). However, much of the IK are yet hardly explored and remains invisible; in turn, there is a grave threat to the extinction of IK (Masinde, 2013; Sarkhel, 2016). Thus, urgent actions are needed for systematic documentation and management of IK as the failure in the management of IK may slow down the rural development.

Knowledge loss is a big challenge for organizations as the economy grows due to the loss of knowledge holders, failure to capture critical knowledge, failure of knowledge repositories and forgetting (Jennex, 2014). The main challenge in all organizations is to efficiently discover knowledge, create new knowledge, capture, store, share, and apply it in order to gain competitive advantage. As such, KM is one that has come to be used to refer to explicit strategies, tools, and practices applied by management that seek to make knowledge as a resource for the organization. Jennex (2005) defined KM as the practice of selectively applying knowledge from previous experiences of decision making to current and future decision-making activities with the express purpose of improving the organization's effectiveness. The purpose KM is to understand, focus on, and manage systematic, explicit, and deliberate knowledge building and application, that is, manage effective knowledge processes and to renew knowledge constantly. The knowledge management function in the organization operates KM processes (i.e., knowledge creation, storage, sharing, and application), develops methodologies and systems to support them, and motivates people to participate in them (King, 2009). The major challenges of KM are the process of knowledge capturing, integration, and sharing.

Previous researches such as Jennex (2009) and Jennex and Olfman (2001, 2006) have suggested that the KM activities need to be supported through KMS in order to foster the organization effectiveness. A KMS, a class of information systems (IS), is a managerial, technical, social, and organizational system structured to support the implementation of KM within an organization thereby enables organization to manage knowledge effectively and efficiently (Arisha and Ragab, 2013). A KMS can be seen as an activity system that involves people making use of objects such as tools and technologies to create artifacts and products that represent knowledge in order to achieve a shared goal (Dalkir, 2005, page 167). It is not, therefore, the technology that distinct KMS from other type of IS; however, it is the highly involvement of human activity in their operation and designed to put organizational participants in contact with recognized experts in a variety of topic areas (King, 2009).

Web 2.0 tools are today widely used to develop an online KMS to understand users' interaction for knowledge sharing and integration (Gaal et al., 2015; Sivarajah et al., 2015). Web 2.0 refers to a set of Web-based technologies such as wiki, blogs, content aggregators, social networking sites, podcasting, and other emerging forms of participatory applications and social media (Gaal et al., 2015; Sivarajah et al., 2015; Wang et al., 2007). Web 2.0 tools are characterized by being user-centered, enhance social network formation, promote communication, interaction, and collaboration, and harness collective intelligence (Wang et al., 2007); thereby help to systematize the processes of knowledge sharing, creation, and integration. For example, social networking tool can be used for connecting people and locate each other with similar interest; Wiki for collaborative, mediated, content production and organization; blogs enable user to subscribe to a blog and post comments in an interactive format; and real time collaboration tools to provide real time voice communication for interaction and knowledge sharing. These tools are important for supporting KM processes including explicit knowledge publishing and the tacit knowledge extraction, dissemination, integration, and utilization across various CoPs having common interest.

THEORETICAL FRAMEWORK

For understanding the integration of knowledge in agricultural KMS development, the theory of situated learning within community of practice (CoP) (Lave and Wenger, 1991) was selected. The theory helps in creating a social infrastructure and view knowledge as socially constructed rather than viewing knowledge as an objective entity. Situated learning is conceptualized as the social context of learning in CoPs and defined as an informal aggregation of individuals engaged in common enterprise and distinguished by the manner in which its members interact and share interpretations (Lave and Wenger, 1991; Wenger, 1998). According to Karner et al (2011), interaction and informal learning in CoP are critical for tacit knowledge capturing, sharing, and integrating with the codified knowledge. In agricultural KMS development, IK having the tacit format possessed by the local communities needs to be captured and integrated in the system. The theory of situated learning within CoP (Lave and Wenger, 1991), thus, provides the concept of knowledge brokering important for understanding knowledge integration across CoPs.

Brokering denotes the activities of individuals that involves facilitating connections, bringing new ideas in and from the outside, and the sharing of knowledge between CoPs across knowledge boundaries (Lave and Wenger, 1991). Knowledge brokers bridge a gap in social organization and support knowledge exchange across knowledge boundaries through enhancing translation, coordination, alignment, and negotiation between different members from different CoPs perspectives (Wenger, 1998), and thereby to facilitate and promote transaction between previously separated practices (Kislov et al., 2016). In the Ethiopian agricultural extension system, there are a group of people named extension agents who are responsible for knowledge and technology transfer to farmers from research. Hence, this research is interested to investigate the roles and practices of extension agents as knowledge brokers in order to understand their contribution in knowledge exchange among relevant CoPs in agricultural KMS development and use.

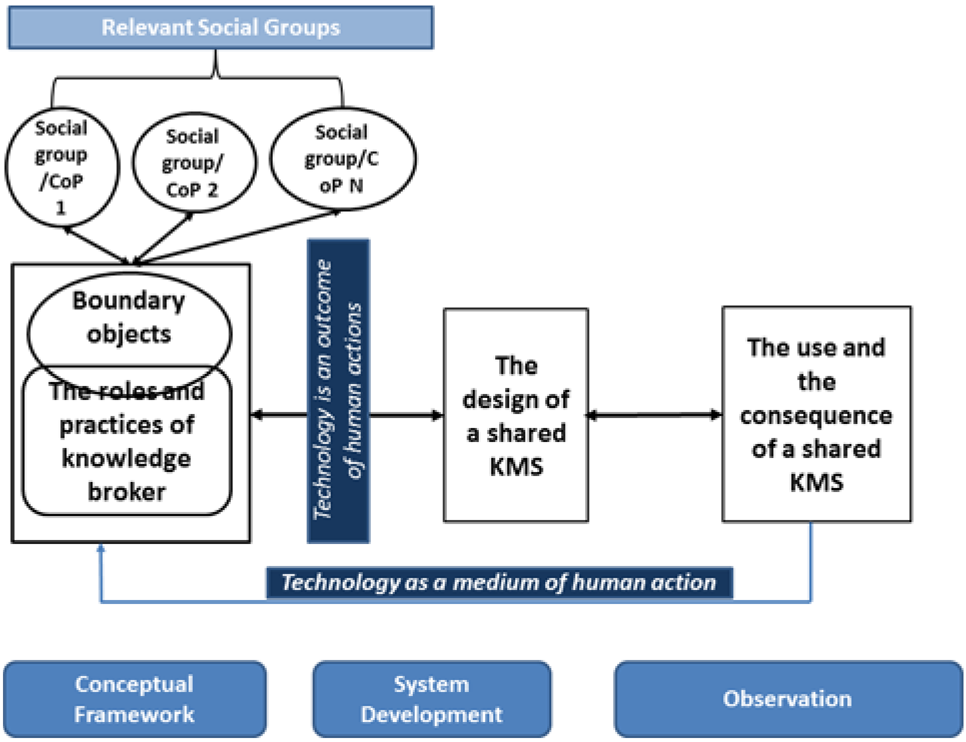
The research also draws theoretical attention to the other concept called boundary objects. They are any objects that are relevant to the practices of multiple communities, but they may be used and viewed differently by each of the CoPs (Rosenkranz et al., 2014), and supporting collaboration, interaction, and knowledge sharing between CoPs within differing perspectives across social and geographical boundaries (Puri, 2007).

However, relatively few studies have investigated how they function in knowledge exchange. Members from different social groups use shared boundary objects for their interactions. IS professionals who develop and support the agricultural KMSs are, therefore, to learn the work practices and objects of each user community. Thus, in the development of agricultural KMS, system developers should involve boundary objects possessed by relevant CoPs in particular local communities in turn the shared KMS as a boundary object enables all relevant participants coming from different CoPs to interact and collaborate for their common practice. As such, this research is also interested in identifying the boundary objects possessed by different relevant social groups.

Several researches further suggested to investigate dynamics technological artifact as boundary object through designing and using the technology for knowledge sharing and knowledge integration (Levina and Vaast, 2005). System development (SD) is, thus, an important practice and research area in understanding the development of the technological artifact through bridging the gap between the technological and the social sides of it. According to Burstein and Gregor (1999), the crucial role of SD is the result of the fact that the developed system can serve both as a proof-of-concept for the fundamental research and provide a technological artifact that becomes the focus of expanded and continuing research. The development and the use of technological artifact as a boundary object can also be used to prove the concepts within socio-technical design science (Miah et al., 2012) for knowledge sharing and integration.

KMS development for knowledge sharing and integration requires an active participation of users not only in the design of the KMS but also in the use of KMS (Germonprez et al., 2011). Technological artifact such as a shared KMS is not only created and changed in the design of it by human action, but also in the use of it to perform some activity (Orlikowski, 1992). Orlikowski (1992) described it as duality of technology consisting of the design and use of time of the technological artifact. Accordingly, this research seeks to understand the design of the technological artifact as a boundary object relying on the roles and practices and boundary objects of different relevant CoPs in agricultural KMS. This in line with the first components of Orlikowski's (1992, p. 409) model (i.e., "*technology as a product of human action*"). Then, the developed technology artifact as a boundary object will serve as a medium for the communication and interaction of members coming from different CoPs (Orlikowski, 1992). Consequently, the research investigates how the shared technology artifact and knowledge brokering is significant for knowledge sharing and integration by relevant social groups through observation. Figure 1 depicts the process conceptual framework of the study using the situated learning in communities of practice (Lave and Wenger, 1991; Wenger, 1998) and structurational

Figure 1. A process conceptual framework for agricultural KMS development and use



model of technology by Orlikowski (1992) for understanding knowledge sharing and integration in agricultural KMS development and use.

RESEARCH METHODOLOGY

This research follows qualitative interpretive paradigm (Klein and Myers, 1999) for better understanding of the integration of variety of knowledge. Nevertheless, understanding concepts merely are not enough in IS research, but system must also be implemented to measure the underlying concepts, thereby to guarantee its sustainability (Burstein and Gregor, 1999). This research is, therefore, applied system development action research approach. Accordingly, the multi-methodological approach to IS in action research perspective which consists of four strategies: theory building, experimentation, observation, and system development is employed. In the first phase, the initial conceptual framework was drawn from the extant literature. Then, the framework further developed empirically. The proposed experimented conceptual framework leads to the development of a technological artifact (i.e., a

KMS) with the intention of illustrating the conceptual framework (Burstein and Gregor, 1999). Finally, the developed system is observed in practice for understanding its use and consequence by members from the relevant social groups.

An agricultural KMS development at an agricultural transformation agency (ATA) provides a theoretically relevant organizational setting for this investigation due to the presence of different groups of participants. Data were collected from local people from two districts of North Gondar Zone of Amhara Regional State of Ethiopia. Primary data were collected by employing in-depth semi-structured interviews and participant observations. Of the total 23 informants, five were agricultural researchers, three technologists, eight extension agents, and seven farmers. The research subjects were selected based on their knowledge and experience. Even though the size of the sample is not large, it is the depth that matters because the researchers were able to keep asking until no new data emerged. Data were immediately transcribed using respondents' own words as fast as possible. Data collection and interpretive analyses were carried out side-by-side (Walsham, 1995). Through the iterative process of data collection and analysis following the multi-methodological approach to IS, the initial concepts were expanded and revised and then used to create a prototype KMS.

RESULT AND DISCUSSION

The research has identified three different social groups in the agricultural KMS development: agricultural researchers, extension agents, and local farmers. Agricultural researchers possess scientific knowledge arises from their educational background, findings of researches and their everyday institutional practices. Local farmers are important source of IK and also use the scientific knowledge and technology from research. However, the KMS development process relies on data extracted from scientific experts and data generated on the basis of recognized scientific principles, draw upon spatial inputs derived mainly from the interpretation of remotely sensed satellite data. This research understood the potential of IK to bring the full potential of the KMS in agriculture and the development needs to blend indigenous and scientific knowledge. In the Ethiopian agricultural extension system, there are extension agents who are transferring knowledge and technology from research to local farmers. The research empirically investigated the roles and practices of extension agents as knowledge brokers.

The Roles and the Practices of Extension Agents

Extension agents in the current agricultural extension system are assumed to play a role in knowledge and technology transfer from research to local communities. There is a gap in agricultural development about the roles and the practices of extension agents as knowledge brokers for knowledge integration in KMS development and use. Accordingly, the research result yields concepts on the roles and practices of extension agent as a knowledge broker for knowledge sharing and integration in agricultural KMS development and use.

In-Betweenness of Extension Agents

The study revealed that extension agents are positioned between agricultural researchers and local farmers and facilitate the knowledge exchange. Extension agents are learning about knowledge and technology from research through training and documents. Then, they teach and consult local farmers at their district. As such, they need to be well positioned to sustain an open and two-way communication with farmers through participating and interacting with them in all levels of agricultural development and KMS development (Hellin, 2012). As such, they can learn from local communities, educate them and engage with them at the requirement elicitation or needs assessment, planning, designing of KMS, implementation, usage, and evaluation levels.

Enhance Participation

An extension agent as a knowledge broker is vital in blending different separate CoPs in agriculture through crossing the knowledge boundaries. They need to cross the boundaries of the local farmers to encourage them to participate and interact with them. Moreover, ability to listen farmers, giving value to farmers' insights and encouraging their decision making are critical in order to strengthen the participation of local farmers. Accordingly, they could facilitate the interaction of members coming from different CoPs and motivate them to participate by crossing the knowledge boundaries and engaging to educate and learn from them in turn exchange knowledge and technology. However, extension agents need to get permission to cross different relevant CoPs both informal local groups and formal social groups (Kislov et al., 2016). This role of knowledge brokering, therefore, requires special qualities of credibility and legitimacy of extension agents in order to cross different social groups (Hellin, 2012) and should take an impartial position.

Network Formation

The information from in-depth interviews indicated the role of extension agents in developing and maintaining relationships among farmers and with other different CoPs through building of a network. During the implementation and planning of agricultural development, extension agents identify and bring people together. In Ethiopia, there are also several types of informal groups in which people gathered together at the community level, for example, funeral groups ('idir'), work sharing groups ('jigie'), and savings and loan–type groups ('iquob'). These groups create an important entry point for and promote linkages to outside actors and serve as a mechanism for transferring knowledge and technology. Extension agents often closely work with such informal networks to strengthen the link between individuals in a CoP. Networking among participants from heterogeneous CoPs can enable to incorporate collective actions (Kislov et al., 2016). Fostering the network of informal groups and the formal groups as a social, institutional, and technical process is crucial for interactive learning (Koutsouris, 2014), thereby encourages knowledge sharing and integration.

Knowledge and Technology Translation

Extension agents translate knowledge and technology from research into different local contexts, and vice versa. Extension agents act as translators, in framing elements of the world view of scientific research in terms of the perspective of local communities. They translate the knowledge and technology from research into another language. Additionally, agents explain how the new knowledge and technology are adopted and implemented in the local farming practices. For this purpose, they understand the local farming context to interpret and apply the new knowledge and technology into the local context. This role of extension agents is not only to translate knowledge from research to farmers but also the vice versa. This is in-line with the argumentation that bi-directional knowledge translation between research and local communities are critical for knowledge integration (Kislov, 2016).

Coordinate Collaboration and Negotiation

Agricultural development is complex problem that requires collaboration and negotiation among various dynamic social groups for developing solutions (Koutsouris, 2014) Extension agents provide conducive environment through coordinating the collaboration and negotiation among relevant participants. They facilitate who and how people work together and negotiate for problem solving, encourage people to contribute knowledge and reflect on others idea, and assist individuals and groups to engage them in a dialogue during the problem-solving process. In particular, extension agents can eliminate the farmer group problem of participation through enhancing a two-way communication with other scientific social groups. Extension agents assist participants to engage in a communicative dialogue and the development of consensus about the action to be taken to negotiate on the scope of the problem to be addressed and consensual solution. In sum, knowledge building and the deep shared understanding are best promoted when the collaboration and negotiation are facilitated through brokers in a dialogic nature.

Boundary Objects

Informants from researcher and extension agent subjects reported a wide range of boundary objects for knowledge sharing among others, ISs, audio visual, guidelines, procedure, system documentation, report printout, publication, newsletter, bulletin, user training manuals, websites, and ICT Kiosks. Local farmers employ observation, traditional music and ceremonies, symbols, farming materials, storytelling, oral expressions, and oral mapping for indigenous knowledge sharing which serve as boundary objects. However, such boundary objects for sharing IK are not considered in the development of agricultural KMS and the KMS does not fully enable farmers to use the knowledge from it and to contribute their own. Consequently, the result of the research implicates the development of a shared KMS through involving the roles and boundary objects of all relevant social groups.

Designing of KMS as a Boundary Object

The KMS needs to support the different participants including extension agent as a knowledge broker, local rural communities, and agricultural researchers. To this effect, critical components of the shared KMS for knowledge sharing and integration are identified relaying on the roles and practices of relevant social groups and boundary objects. Following the terminologies presented by Saade et al (2011) and Jung et al (2007), three basic subsystems of KMS were identified: the people subsystem, the resource subsystem, and technological subsystem.

In building this research, the human subsystem includes local farmers, agricultural researchers, and extension agents, who are the core of the agricultural KMS. In order to share and integrate knowledge, active participation and collaboration among these social groups are highly critical in the KMS development process. Hence, development of the KMS was carried out by paying attention to those people. Table 1 indicated the human agents and their roles in the development of agricultural KMS. The resource subsystem consists of knowledge resources from the local and scientific communities and rules including guidelines and procedures for social interaction in agricultural system development. The KMS also consists of technological artifact and processes used by users from different social groups to support KM activities (Jennex and Olfman, 2001). To this effect, the implementation subsystem is primarily concerned with the identification and development of applications for supporting KM activities in particular knowledge sharing and integration.

Table 1. The roles of relevant social groups in KMS development

Social Groups	Roles
Agricultural Researchers	Scientific knowledge systems creation, recreation, and presentation Use IK from local farmers for further research Interact with extension agents Evaluate the ongoing implementation of new knowledge and technology
Local farmers	Indigenous knowledge creation, recreation and presentation Use scientific knowledge and technology from research Interact with extension agents and researchers
Extension agents as knowledge brokers	Extension agents exchange knowledge and technology between farmers and researchers.

Web 2.0 tools were used to develop a tailorable technological artifact in order to understand actionable changes to KMS function or content (Germonprez et al., 2011) for knowledge sharing and integration. Web 2.0 tools were employed in this study to provide various ways of interaction among people to share users contributed contents, develop content collection by user community, and to create and modify artifacts for content contribution and interaction. The Web 2.0 tools were selectively employed in various ways with the corresponding KM activities in particular for knowledge sharing and integration. Additionally, the selection process involved the needs, skills and expectations of relevant CoPs members in agricultural KMS.

The Use of KMS as a Boundary Object

We provided access to 23 informants from local farmers, agricultural researchers, and extension agents to an online KMS following its development from February 2017 to April 2017, who were voluntary to participate in the research. Finally, participants are observed while using the system and further interviewed the informants for understanding of the significance and the consequence of a shared KMS as a boundary object.

During the use of the online KMS, we observed the communication and participation of participants from local communities and research groups who are located in distant and geographically disparate locations. Their communication and interaction employed several forms such as text-based (chat), voice and video communication through instant messaging, audio and video conferencing, and podcasting. As such, the attractiveness of these Web 2.0 tools lies in the direct contact between participants whereby highly decrease the feeling of distance among them. Moreover, audio and video communication and mapping in the KMS foster the externalization of indigenous tacit knowledge from local farmers through visualization. The shared KMS is highly important not only to reach geographically disparate users and enhance the interaction between researchers, extension agents and farmers but also provides a distributed environment to disseminate knowledge in all directions instantly. The use of the KMS can also eliminate the existing hierarchical structure of the country extension system, which promotes one-way knowledge and technology dissemination from research to local farmers.

The participants from the rural communities and agricultural researchers access the existing knowledge, enriching dialogue/forum to enhance interaction, contribute their knowledge and create new knowledge. Knowledge contents presented in different languages (i.e., farmers' local language) and presentation of content in different forms (i.e., textual, image, audio, and video) enables farmers and others to easily access information and be able them to interact. Farmers share their own knowledge (i.e., indigenous knowledge) using oral mapping, storytelling, and observation. Hence, audio blogging and podcasting, instant message, and visualization tools employed in the KMS help farmers to access knowledge from others and share their own.

The online KMS enables users to connect with others informally in their CoPs and with other users from different CoPs. The social network tools in the shared KMS also enable them to identify the knowledgeable and interact on one-to-one, one-to-many, and many-to-many among users from different CoPs independent of the existing hierarchical structure of the extension systems. Such networking is important for exposing users to different knowledge. Consequently, users from different groups highly communicate, interact and collaborate for their common interest, whereby, knowledge sharing and integration are enhanced. Some of the comments from users of the KMS boundary object:

The system is now easy for us to use. I join extension agents and agricultural researchers who can help me through providing information. I also received updates through the system. (Farmer-Respondent #14)

Many of the farmers have a difficulty to read textual contents from the website. However, this website provides information in different forms especially audio and visual format. As a consequence, farmers can listen audio contents and see images and videos, thereby they interact each other and with other CoP. (Extension-Agent-Respondent #8)

I can access information in different forms such as textual, audio, image, and video in my own language (i.e., Amharic language). I can also share my own to others. (Farmer-Respondent #7)

An online shared KMS enables us to foster communication and interaction of users from different social groups desperate geographically. (Extension-Agent-Respondent #9)

Farmers and extension agents can easily communicate and interact with us by using this KMS. It is very important for us to reach many extension agents and farmers. Consequently, the usage of it can avoid the existing hierarchical structure, thereby to exchange knowledge between farmers and research. (Agricultural-Researcher-Respondent #5)

It is now easy for us and even for farmers in our kebele to use this system and to perform our roles of knowledge brokering and use knowledge from different sources from it. This is because the system is accessible in our local language, have user friendly interface, and it provides different contents and functionalities relevant for our roles of knowledge transfer. (Extension-Agent-Respondent #4)

The Consequence

The roles of extension agents as knowledge brokers and a shared KMS as a boundary object have brought the consequences for knowledge sharing and integration including,

- Knowledge sharing among participants from different CoPs and
- New knowledge creation through integration.

The shared KMS developed using Web 2.0 tools with knowledge brokering activities support further-reaching and more innovative to connect with a large number of users from different CoPs. The mediators (KMS and broker) aid users to accelerate the flow and reach of divergent knowledge. As this study demonstrated, the mediators foster the externalization of tacit knowledge since it promotes the participation of all relevant users and enables them to interact and collaborate with each other. As a result, users contribute their knowledge and experience. Especially local farmers share their indigenous knowledge to other members of CoPs. The interaction among participants from different CoPs enables users to share their knowledge and experience. Knowledge with tacit format can be shared among participants, convert tacit knowledge to explicit knowledge and preserve diverse knowledge systems in the repository, and moving it to the other formal and informal groups.

The knowledge boundary that exists across different occupation groups become an opportunity to integrate knowledge (Lave and Wenger, 1991; Carlile, 2004) through the interplay of mediators and a KMS. The interplay of the mediators creates an ongoing two-way communication and interaction across participants from different CoPs. Users from different groups are exposed to diverse knowledge and linked to key knowledge resources. Consequently, users can access knowledge from different sources, reflect on others thought, and learn from others in turn knowledge from different sources can be integrated.

KMS Evaluation

The last phase in this system development action research is to assess the success of the interplay of the developed technological artifact and the roles and practices of knowledge brokers in the study's social context to understand the use of the KMS and the consequence of the usage. The success of the interplay of extension agents as knowledge brokers and KMS boundary object was assessed using Jennex and Olfmans' (2006) model of KM/KMS success dimensions. The interplay of the roles of brokering and a shared KMS boundary object is enabled through the structural properties of social systems and these may be sustained or changed when being used by human agents. The organizational structural properties and the condition of the technological artifact are essential to understand the success of the KMS/KM in the agricultural extension system. Accordingly, the study assesses and discusses the critical success factors for the interplay on the structural properties of social systems or organization through the dimensions including the system quality, knowledge quality, and service quality as functional drivers to understand the system use and impact (Jennex & Olfman, 2001, 2006; Jennex, Smolnik, & Croasdell, 2016).

KMS Quality

Jennex and Olfman (2001) described the system quality factor as how good the KMS/KM is in its operational characteristics in order to perform the KM activities such as knowledge creation, storage, transfer, and application. It also addresses how much extent the knowledge system is represented in the knowledge repository of the KMS and the KM/KMS infrastructure integration (Jennex & Olfman, 2006). Jennex and Olfman (2006, 2001) defined the system quality factor with three constructs: technological resources of the organization, KM/KMS form, and KM/KMS level.

This research found that the existing technological infrastructure in the organization and a common infrastructure (i.e., the Internet) have the capability to process both the scientific and indigenous knowledge. In building this research, integrated technological infrastructure in a KMS consists of networks, search engine, groupware tools, databases and knowledge repositories, computers/clients, web server, database server, web server software, and client and server scripting languages. Additionally, the KMS integrated users' requirements and expectations, relevant social groups' competency in KM activities, knowledge brokering roles and practices by extension agents, and boundary objects possessed by relevant CoPs. However, the existing infrastructure lacks the integration of data mining tools for extracting patterns and knowledge from the existing knowledge and documents. Integrating technological infrastructures and organizational capabilities provides the KMS interpretative flexibility (Sahay & Robey, 1996). The interpretative flexibility is an important technological condition for a KMS to allow all relevant users to use it for supporting the KM activities and contributing their knowledge and perspective.

A shared KMS boundary object provided interpretatively flexible to be used by different participants to promote communication, interaction, and collaboration among relevant participants for knowledge sharing and integration and supports them to build shared understanding. The KMS enables all relevant users to perform the KM activities through possessing both indigenous and scientific knowledge. The past experience applied for developing and managing scientific knowledge can also be applied for possessing indigenous knowledge. Additionally, the system provides a user friendly interface with appropriate language of users and enhances communication and interaction among users so as to support the users' roles and practices and delivers relevant information and knowledge timely to individuals. Previous researches indicated that integration of KMS/KM infrastructure and organizational capabilities can enhance individual performance and organizational effectiveness (Jennex, 2013; Jennex & Olfman, 2001, 2006).

Integrating the technological infrastructures and organizational capabilities enables the KM/KMS form and KM/KMS level constructs (Jennex & Olfman, 2006). Jennex and Olfman (2001) defined the KM/KMS form as the extent to which the knowledge resources and KM activities are computerized and integrated. Web 2.0 tools have been integrated in the development of KMS in order to support KM activities and representation of knowledge systems

Jennex and Olfman (2001) described the KM/KMS level construct as the ability to provide knowledge from different sources to support current activities through KM/KMS mnemonic functions of knowledge searching, visualization, retrieval, assessment, and manipulation. The architecture of this KMS incorporated integrative and interactive applications in order to provide knowledge assessment, visualization, searching, and content management and supports network formation, interaction, collaboration, and negotiation among members coming from different CoPs. Additionally, searchability facilities in a KMS allows users to access knowledge systems necessary to get jobs done. Also, a shared KMS fosters the roles and practices of knowledge brokering. Subsequently, the interplay of a shared KMS and the roles of knowledge brokering allows users to access diverse knowledge from a number of users in different groups of participants and an efficient exchange of different forms of knowledge. It also offers enhanced learning environment through supporting local farmers' participation, formal and informal conversations, and open dialogue. Consequently, the KMS helps users to access, share, and integrate knowledge so as to support their roles and practices effectively.

Knowledge Quality

Jennex and Olfman (2001, 2006) described the knowledge quality dimension as the incorporation of the knowledge and KM activities to capture the right knowledge with its context and to provide it to the right users at the right time. It consists of three constructs: KMS/KM strategy and process, linkages to knowledge, and richness of knowledge (Jennex & Olfman, 2001, 2006). The KMS/KM strategy and process construct refers to the organizational processes for identifying knowledge users, sources, processes, and knowledge capturing, storage, sharing, and integration in a KMS/KM. It is crucial for ensuring the contents and effectiveness of the constructs of linkages and richness of the knowledge systems (Jennex & Olfman, 2001, 2006).

An online KMS boundary object supports the roles and practices of individuals from local communities, extension agents, agricultural researchers, and system developer groups and represents associated knowledge systems. It is essential to store, share, and integrate relevant knowledge for agricultural productivity in the knowledge repository. Also, the KMS supports knowledge access through locating knowledge and experts. KM activities for knowledge sharing and integration through capturing, disseminating, and combining tacit indigenous knowledge with explicit scientific knowledge are clearly articulated and easily understood to ensuring the users' knowledge requirements and expectations. As a result, a KMS with knowledge brokers creates an online open learning environment in the agricultural extension system through providing participative, interactive, and collaborative culture, which are essential for knowledge sharing and integration.

The construct richness refers to the accuracy and timeliness of the stored knowledge in a KMS with its context to make the knowledge useful for decision making (Jennex & Olfman, 2006). Knowledge and information from various sources in different formats have been provided through the KMS including numeric, audio, video, text, and image formats with appropriate users' language. Accordingly, a combination of indigenous and scientific knowledge is shared among participants and available timely for decision making. Additionally, the construct linkages are crucial to assess the knowledge and experts maps in a KMS/KM to locate the sources of knowledge to the participants (Jennex & Olfman, 2006). Users can join different social groups such as local communities, researchers or extension agents to locate experts and exchange knowledge among members within a social group or among different social groups. Also, knowledge and documents possessed by each social group are available to users in a KMS. As a consequence, novice users can learn and apply new knowledge and reflect and share their own knowledge and experience. This is essential to exchange indigenous knowledge having tacit format and for sourcing to the richness of knowledge systems.

Service Quality

Jennex and Olfman (2006) defined the service quality dimension as the adequacy of the KMS/KM to support users to utilize KMS/KM effectively. This dimension consists of three constructs: management support, user KM/KMS service quality, and KMS/KM service quality (Jennex & Olfman, 2006). The management support construct reflects the organizational capability such as organizational or social properties and structure to provide resources to create and maintain KM/KMS, enhance knowledge sharing culture, and avail encouragement, incentives, and control structure for knowledge exchange (Jennex & Olfman, 2006). The KMS provided open non-hierarchical organizational structure through promoting one-to-one, one-to-many, and many-to-many communication and interaction among participants.

Wenger (2000) suggested that a system as a boundary object is more useful, when it is designed to enable multiple practices to negotiate, create relationships and expose users to different knowledge. For this purpose, a KMS enables users from different CoPs to connect with others from different communities, in turn users are exposed to different perspectives and knowledge. A shared KMS is highly important not only to reach too many users geographically disparate and enhances the interaction between researchers, extension agents and farmers but also provides distributed environment to disseminate knowledge in two-way mode instantly. In particular, people in the rural area establish relationship and interaction informally. As a result, the interplay of KMS and brokering has brought nonhierarchical structure for knowledge sharing. It surpasses the existing bureaucratic hierarchies and creates informal communities having common interest, in turn fosters communications and interaction among participants.

Wenger (2000) pointed that an organizational structure is an overarching umbrella which needs to involve diverse relevant social groups through specifying their roles, practices, and relationships. The interplay of brokering and a shared KMS witnessed a paradigm shift in Ethiopian agricultural extension program organizational setting from hierarchical structure to decentralized structures, networked, dynamic, and open learning environment. As a result, collaborative culture is more likely to occur through the support of the KMS/KM, which is vital for knowledge sharing.

Jennex and Olfman (2006) described the user KMS/KM service quality as the support provided by the organization to help their employees and users to utilize KMS/KM (Jennex & Olfman, 2006). The support includes raising awareness and providing training to users on how to use a KMS for supporting their roles and practices and incentives to reward user for knowledge sourcing and encouraging participants to communicate and collaborate with others. The research resulted in identifying limited skills and knowledge of extension agents in the Ethiopian extension system to enhance their roles to knowledge exchange and integration. These skill and knowledge are expected to enable brokers to be efficient and effective, thereby they can facilitate knowledge exchange.

Interaction between human agents and the technological artifact in an organization requires rules that govern legitimate conduct (Orlikowski, 1992). In building this research, a KMS developed using Web 2.0 involves procedures, guideline, and privacy issues since they are essential in an open system to allow participation, communication, and negotiation of individuals among each other. Additionally, complementing traditional agricultural extension system with a KMS is considerably changing the roles of relevant social groups in the context of knowledge sharing and integration, especially the roles of extension agents as knowledge brokers. As consequence, their roles need to be clearly defined and appropriate training needs to be provided by KMS developers on KM activities and KMS use. According to Kislov et al. (2016), knowledge brokers need to have a good understanding of research evidence codified in the form of guidelines, protocols and pathways. In addition, the participants'' roles and practices need to be well thought out to enhance online participation, content provision and to foster collaboration through a shared KMS boundary object (Flor, 2013). Accordingly, there is a need to set up clear rules and procedures with regard to how local farmers, extension agents, and researchers behave when they use a KMS.

Common problems in using an online shared KMS employed Web 2.0 tools are intellectual property issues such as copyright and privacy, in particular the documentation of indigenous knowledge and practice. In this regard, raising awareness with participants and documentation are highly important. For instance, website's terms and conditions are considered as copyright for the materials uploaded. It is further important to document and present general 'Dos' and 'Don'ts' to the participant regarding the use of a KMS. Additionally, users may require to present their knowledge content to some other selective users. Users may also afraid to ask others publicly over the online the KMS. For this purpose, this KMS has activity privacy setting which allows the members to choose who can read/see his/her activities and media files. Overall, a comprehensive set of policies needs to be well prepared to foster knowledge sharing and integration.

Intent to Use/Perceived Benefit

The intent to use/perceived benefit dimension is a construct that measures perceptions of the benefits of KMS/KM by users on meeting current and future users' needs and expectations (Jennex & Olfman, 2006). This research discusses the perceived benefit of the KMS usage by extension agents through examining the roles and practices of extension agents as knowledge brokers and by the end-users (i.e., farmers and agricultural researchers) for knowledge use and contribution in an increase in job performance and productivity. A shared KMS in this research has been developed to support brokering roles and practices and users from local farmers and researchers to use and contribute their knowledge and perspectives. Despite the significant roles of a shared KMS as a boundary object for knowledge sharing and integration, a KMS did not replace the need of knowledge brokers. Extension agents as knowledge brokers in this regard still contribute a mediation role among geographical distributed social groups and technically support local communities in the use of a KMS.

KMS/KM Success Determination

This research considers the KMS/KM effective and successful for knowledge sharing, creation, and integration in the organization. In this organization (i.e., the agricultural extension system), the integration of KM/KMS infrastructures support the relevant users and manages knowledge resources. Multiple channels for communication, interaction, and collaboration are provided via the KMS for knowledge exchange. Additionally, the KMS/KM provides quality knowledge to the right users in extension program. Through the interplay of brokering and a KMS, knowledge from different sources are identified with relevant experts so as to support the KM activities in collecting knowledge from different sources as an asset. This is crucial to understand the knowledge need and how it is applied for the users' roles and practices. Additionally, providing the quality knowledge within the context of users enhances the re-use of knowledge and effective decision making. This is also in-line with the KMS/KM success definition, that is providing the right knowledge to the right users at the right time (Jennex, Smolnik, & Croasdell, 2009).

The KMS/KM is also successful in providing a conducive organizational culture that encourages knowledge sharing and sourcing. In building this research, it has been demonstrated in creating open collaborative culture in the extension program, which is critical for knowledge exchange and use. However, organizational culture regarding KMS/KM activities such as rewarding system, mutual trust, and trainings are required in the Ethiopian extension system. Successful KMS/KM can bring open learning environment to facilitate knowledge sharing but needs a trust-based organizational culture. Additionally, the research revealed the potential of IS experts in the organization who can provide help to the KMS users and sustain the KMS implementation, maintenance, and use.

Finally, the findings of the study indicated that the implementation and use of the KMS/KM is successful in improving the individuals' performance and the organization effectiveness. Accessing quality knowledge timely by relevant participants is highly important to make decision effectively. Local farmers in Ethiopia are not productive and are vulnerable to food insecurity due to the lack of timely quality knowledge about soil fertility treatment and climate change. Hence, the successful implementation of

KMS/KM helps users access quality knowledge. The KMS supports users to share, re-use, and contribute knowledge, thereby improves the users' performance to get the job done. Obviously, users' task performance is the most significant human output contributing to the effectiveness of organization.

CONCLUSION

In order to share and integrate knowledge, it is critical to identify the relevant social groups, their information needs and the knowledge they possess. In the case of agricultural KMS development, the research identified social groups who possess different knowledge who are capable of influencing the KMS development and use. In this research, there are local farmers who possess IK and agricultural experts who possess scientific knowledge. However, result of this research indicated that knowledge in agriculture have been applied in an isolated and fragmented manner. Despite many challenges in the integration and sharing of knowledge, their amalgamation can be expected to bring agricultural productivity.

The study investigated the roles and practices of extension agents as knowledge brokers for knowledge sharing and integration in KMS development and resulted in five themes. Consequently, the roles and practices of extension agents as knowledge brokers can have a potential to bridge the knowledge boundaries through exchanging knowledge among participants. As a result, relevant organizations are required to give attention to the roles and practices of extension agents as knowledge brokers to enhance the knowledge management activities. However, understanding the roles of brokering is not only enough to understand knowledge sharing and integration, but there is also a need to investigate the role of boundary objects.

Despite the fact that several boundary objects are identified in the agricultural KMS development process; boundary objects employed by local farmers for IK sharing, preservation, and integration are not considered in the current KMS development process. In response, a shared KMS for knowledge sharing and integration is designed to address the challenges raised by diverse groups of participants. The research demonstrated the use of a shared KMS by a large number of users coming from diverse CoPs in a distributed environment. Thus, a shared boundary objects should be flexible to be used by different participants to promote communication, interaction, and collaboration among relevant participants for knowledge sharing and integration.

The interplay of a shared KMS and the roles of knowledge brokers can allow users to access diverse knowledge and an efficient exchange of different forms of knowledge. Additionally, the interplay of mediators can create highly participative, collaborative, and negotiation culture, which are critical for knowledge sharing and integration in turn owners of the problem can collectively solve their problem. Consequently, knowledge sharing among participants from different CoPs and new knowledge creation through the integration of the existing knowledge are highly fostered. Despite the fact that the roles of knowledge brokers and boundary objects are the central point for knowledge sharing and integration, the existing hierarchical structure requires restructuring to support brokering and a shared KMS as a boundary object.

The contributions of the research include theoretical, methodological, and practical implications. Theoretically, the study can advance the literature on the roles and practices of agricultural experts as knowledge brokers and a shared KMS as a boundary object for knowledge sharing and integration. It can also contribute in extending the theory of situated learning in community of practice (Lave and Wenger, 1991; Wenger, 1998) and the Orlikowski's structuration model of technology (Olikowsk, 1992) for understanding knowledge sharing and integration in KMS development and use.

The methodological implication of this research is two-fold: understanding of the application of systems development action research approach on the one hand and in extending the design science approach, on the other. It is significant for investigating the requirement through theoretical understanding, further important to examine how technological artifact is designed, and also enables to understand the use and the consequences of the technological artifact, whereby a comprehensive conceptual framework for KMS development can be coined. Therefore, the research contributes methodologically for the use of system development for a complete understanding of a complex research area such as KMS and DSS. In addition, it can also contribute in extending the design science approach coined by Hevner et al. (2004) for understanding the use and the consequences of the KMS. Hevner's et al. (2004) approach assumed the design of information systems is completed before it is placed in use context and engaged by users [29]. However, users can also influence the technological artifact while using the system through knowledge sharing and modifying the technology. This research can, therefore, contribute in extending the design science approach in an understanding of the participation of end users in the use time of the technological artifact.

Practically, the research can provide management understanding in developing strategies and utilizing for the potential of extension agents as knowledge brokers for knowledge sharing and integration. It can also provide management insight on the roles of boundary objects and Web 2.0 tools for KM activities and KMS development ultimately to support marginalized and poor smallholder farmers.

Finally, while the developed shared KMS boundary object appears to be successful, future research will be necessary to ensure the sustainability of the system.

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Chapter 14
Using Knowledge Management and Machine Learning to Identify Victims of Human Sex Trafficking

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ABSTRACT

Social media and the interactive Web have enabled human traffickers to lure victims and then sell them faster and in greater safety than ever before. However, these same tools have also enabled investigators in their search for victims and criminals. Authors used system development action research methodology to create and apply a prototype designed to identify victims of human sex trafficking by analyzing online ads. The prototype used a knowledge management approach of generating actionable intelligence by applying a set of strong filters based on an ontology to identify potential victims. Authors used the prototype to analyze a dataset generated from online ads

DOI: 10.4018/978-1-7998-2355-1.ch014

from southern California and used the results of this process to generate a revised prototype that included the use of machine learning and text mining enhancements. An unexpected outcome of the second dataset was the discovery of the use of emojis in an expanded ontology.

INTRODUCTION

Trafficking humans for sexual exploitation is a fast-growing criminal enterprise even though international law and the laws of 158 countries criminalize sex trafficking (Equality Now, 2017). The Equality Now (2017) *Sex Trafficking Fact Sheet* lists these statistics:

- Sex trafficking is a lucrative industry that makes an estimated US$99 billion a year.
- About two million children are exploited every year in the global commercial sex trade.
- Women and girls make up 96 percent of victims of trafficking for sexual exploitation.

Further, human trafficking is not just a third or developing world problem. The National Human Trafficking Resource Center hotline lists 5784 human sex trafficking cases reported in the United States during 2016 (NHTRC, 2018a). Additionally, the National Human Trafficking Resource Center has reported that California had 1050 of these cases (NHTRC, 2018). (Note that this chapter and research uses a sample set from California, United States and so statistics, policies, and laws used in this chapter are focused on this region)

The U.S. Government defines human trafficking as inducing others to perform a commercial sex act by force, fraud, or coercion; as inducing a person under 18 years of age for such an act; and/or as recruiting, harboring, transporting, providing, obtaining a person for labor or services through the use of force, fraud, or coercion in order to subject them to involuntary servitude, peonage, debt bondage, or slavery (National Institute of Justice, 2012). However, the Department of Homeland Security (DHS) has more recently shortened the definition of human trafficking to a contemporary form of slavery that involves the illegal trade of people for exploitation or commercial gain (Department of Homeland Security, 2014). Further clarifying this definition, California's Department of Justice (DOJ) has stated that human trafficking is a contemporary form of slavery that involves controlling a person through force, fraud, or coercion to exploit the victim for forced labor, sexual exploitation, or both (Harris, 2012). While slightly different, all three definitions are similar in context. However, for this paper, we use California's DOJ's definition but note that two classes of human sex trafficking exist: those for victims under 18 (minors) and those for 18 or over.

In this paper, we focus on the sex trafficking aspect of human trafficking and propose an information systems approach to identify sex trafficking victims based on analyzing online (Internet) ads. We focus on online ads because social media and the interactive Web have enabled traffickers to lure victims and sell them at a faster rate and in greater safety than ever before. However, these same tools have also created new avenues for prosecution and criminal investigations for law enforcement as officials now have access to a vast amount of information about the sex industry. We use system development methodology from action research (Nunamaker, Chen, & Purdin, 1990; Burstein & Gregor, 1999) with a knowledge management strategy approach of identifying actionable intelligence (i.e., identifying victims of human sex trafficking) by applying a set of strong filters based on an ontology of keywords that codifies attributes of human sex trafficking victims to assess an unstructured dataset consisting of the text from online ads scraped from the women looking for men section of backpage.com.

Specifically, we address the following research question:

RQ: Can one use online data to identify victims of human sex trafficking?

To answer this question, we created a prototype to explore text-based indicators of human trafficking in online classified ads (see section 4.1 for a list of these terms). In particular, we created the prototype to:

- Create an ontology/keyword list of terms and/or attributes that may indicate human trafficking
- Create a process for extracting an unstructured text dataset from online advertising, and
- Use the keyword ontology to construct strong filters that can be applied to the unstructured dataset to determine ads that create actionable intelligence on identifying victims of human sex trafficking.

Additionally, during the study of keywords in online ads we discovered that emojis were being used in lieu of keywords leading to the addition of the following purpose for the final prototype (see section 5.2.2 for the emojis identified as being used in human sex trafficking):

- Add emojis to the keyword ontology and use them to construct strong filters that can be applied to the unstructured dataset to determine ads that create actionable intelligence on identifying victims of human sex trafficking.

The prototype we created utilized: Strong filters that combined knowledge/experience-driven ontologies of keywords and emojis that modeled human sex trafficking victims

- A process for updating the ontology
- A process for extracting an unstructured dataset of online ads, and
- A process for analyzing the unstructured dataset using evaluation criteria for determining what ads are actionable

Technologies in the prototype included ontologies, machine learning, text mining, and Web scrapers.

KNOWLEDGE MANAGEMENT, TECHNOLOGIES, AND TRAFFICKING INDICATORS LITERATURE REVIEW

Knowledge Management

We used a knowledge management, KM, approach to develop and apply ontologies (defined later) to create strong filters to help identify potential victims of human sex trafficking in online advertising. In this section, we review the literature and theoretical base for using knowledge management to help develop a system implementation to assist in searching for human sex trafficking victims.

Davenport and Prusak (1998) view knowledge as an evolving mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. They found that, in organizations, knowledge is often embedded in documents or repositories and in organizational routines, processes, practices, and norms. They also say that, for knowledge to have value, it must include the human additions of context, culture, experience, and interpretation. Polanyi (1967) and Nonaka and Takeuchi (1995) describe two types of knowledge: tacit and explicit. Tacit knowledge (commonly known as unstructured knowledge) refers to knowledge that individuals understand in their minds and that data or knowledge representations cannot directly express. In contrast, explicit knowledge (commonly known as structured knowledge) refers to knowledge that that knowledge representations can directly express.

Jennex (2005) defines KM as the practice of selectively applying knowledge from previous decision-making experiences to current and future decision-making activities to improve an organization's effectiveness. Also, Jennex views a KM system (KMS) as a system created to help individuals and organizations capture, storage, retrieval, transfer, and reuse knowledge. Jennex (2005) perceives KM and KMS as ideally holistically combining organizational and technical solutions to retain and reuse knowledge and, thus, to improve organizational and individual decision making. This view coincides with Churchman's (1979) view of KM that allows KMS to take whatever form necessary to accomplish these goals. Holsapple and Joshi (2004) provide another key definition of KM: they consider it as an entity's systematic and deliberate efforts to expand, cultivate, and apply available knowledge in ways that add value to the entity in the sense that it creates positive results from accomplishing objectives or fulfilling its purpose. Finally, Alavi and Leidner (2001) conclude that KM involves distinct but interdependent processes of knowledge creation, knowledge storage and retrieval, knowledge transfer, and knowledge application.

Jennex (2017b) incorporates big data and the Internet of things (IoT) (see Figure 1 below) into Jennex and Bartczak's (2013) modified knowledge pyramid and uses the final revised pyramid to define the purpose of KM as identifying, generating, capturing, and using actionable intelligence. Actionable intelligence is that knowledge that can be directly and immediately applied to make a decision. KM processes filter IoT, big data, data, information, and knowledge to generate specific, actionable intelligence that the organization can share with specific, limited users. Additionally, Jennex (2017b) places filters on social networks to limit access and to separate and capture that which the organization needs from that which it does not. In this vein, "filters" is a fairly new term for KM, and we view KM filters as the implementation of KM strategy. Figure 2 (Jennex, 2017a) shows the components necessary for successful KM. While KM requires all the components in the figure and we use them all in this research, we consider KM strategy and KM content the most important in designing and implementing the prototype that we present in this paper. KM strategy determined needed actionable intelligence, guided us in determining what data and information to collect, and finally guided us in designing and constructing the filters.

KM content (see Figure 2) is the process used in KM to ensure the KM system has captured the knowledge necessary to process data and information into actionable intelligence. We used the experiential knowledge that we present in Section 2.2 as the key knowledge applied in the prototype. Experiential knowledge refers to framed knowledge (in this paper, knowledge about sex trafficking victims) that guided us to select and apply the right technologies and ontologies to create appropriate filters for processing the data and information that we gathered.

Ontologies codify knowledge by providing a simplified and explicit specification of a phenomenon that one desires to represent (Gruber, 1995; Noy and McGuinness, 2001; Staab, et al., 2001). Ontologies are useful because they explicate components that define a phenomenon and, thus, can help in systematically understanding or modeling that phenomenon (Holsapple & Joshi, 2004). Keywords/terms are specific examples from an ontology with a complete set of keywords/terms that define an ontology. Ontologies are a sub-domain of KM.

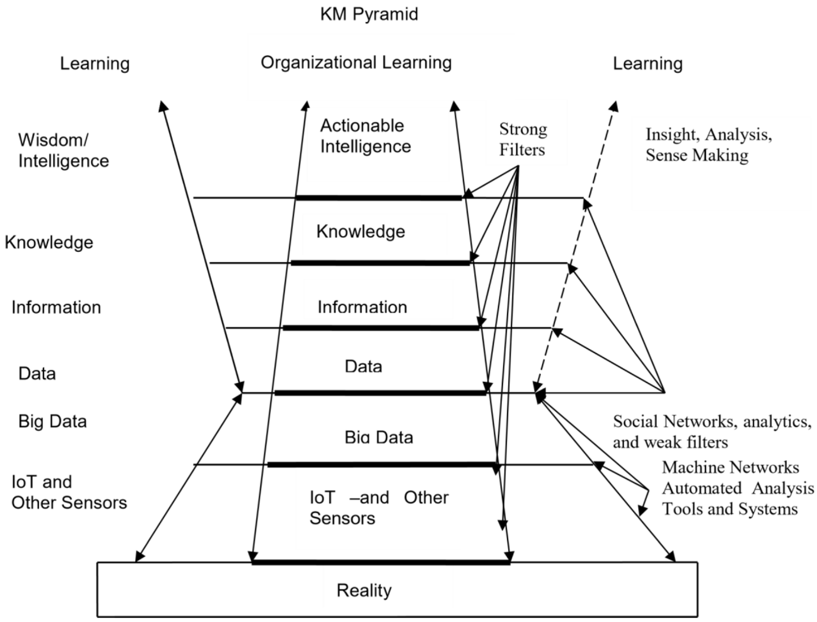
Alavi and Leidner (2001, p. 114) define a KMS as "IT (Information Technology) based systems developed to support and enhance the organizational processes of knowledge creation, storage/retrieval, transfer, and application". Many researchers include ontologies in the KMS as tools for organizing and retrieving knowledge (Aldea et al., 2003; Almeida & Barbosa, 2009; Holsapple & Joshi, 2004; Jurisica, Mylopoulos, & Yu, 1999; Varma, 2007; Wu & Yang, 2005).

We created ontologies by identifying keywords from the experience literature that describes the phenomenon of human sex trafficking. We then used our first ontology in a KMS that applied the ontology to a set of unstructured ad data to create actionable intelligence that we could use to identify potential victims of human sex trafficking in online advertising. Subsequently, we created a new ontology based on more current literature and a second dataset and then used machine learning tools to enhance this ontology based on patterns in the ad dataset and applied the enhanced ontology to identify potential victims of human sex trafficking in the second dataset. In the future, we plan to use machine learning tools to automatically generate an ontology from a new dataset.

Technologies for Combatting Trafficking

Amin (2010) discusses the potential benefits of using machine learning as a tool to combat human trafficking. These benefits include; detecting features and unusual patterns indicative of potential cases of human trafficking, identifying rules that can assist in predicting trafficking activity and profiling victims and criminals, and help in automating pattern identification and search process for potential instances of trafficking online. One application of machine learning techniques for combatting online sex trafficking involved the use of a sample of backpage.com ads from March 2016 to train a learning classifier. The ads collected from backpage.com were first filtered using known indicators of online sex trafficking and feature engineering. The six categories used for creating the feature set included; ad language pattern, words and phrases of interest, countries of interest, ad of multiple victims, weight of victim, and whether the ad reference an external website or spa massage therapy. Following this unsupervised filtering, a small portion of the remaining ads were then labeled by human experts as to whether they were instances of human sex trafficking.

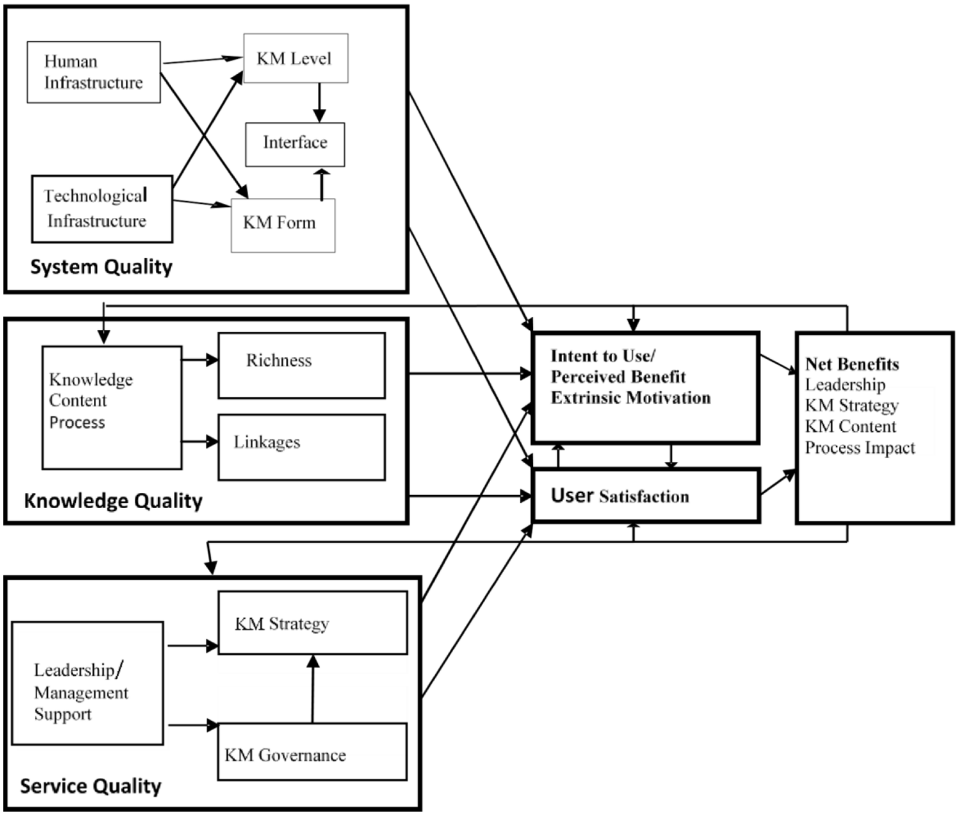
Figure 1. The Final Revised Knowledge Pyramid (Jennex, 2017b)



A semi supervised learning algorithm was then used to label the remaining ads and the classifications were then reviewed by experts in online sex trafficking to evaluate accuracy. Radial basis function (92.41% True Positive Rate) and K-nearest neighbor (90.42% True Positive Rate) kernels were used to assign classifications and both learning models were able to predict online instances of sex trafficking with high accuracy (Alvari, Shakarian, and Snyder, 2016). This study indicates the high potential of using machine learning techniques to identify ads that are potentially human trafficking related. Additionally, the use of semi-supervised methods makes the modeling technique more realistic for real world application because obtaining large enough samples of labeled data for a purely supervised learning algorithm is not very plausible.

Dubrawski, et al. (2015) trained multiple random forest models using three differed information extraction approaches, term-frequency analysis using law enforcement provided keywords, regular expressions, and natural language processing. Of these three, the natural language processing feature set had the highest accuracy in predicting actual instances of human sex trafficking, lowest false positive rate, followed by the keyword feature extraction method. The natural language processing feature set was obtained by compiling a bag of words from online escort ads and then using principle component analysis for dimensionality reduction (Dubraski, et al., 2015).

Figure 2. Revised Jennex-Olfman Success Model (Jennex, 2017a)



Research on the use of machine learning techniques to combat child sex trafficking has also involved the architectural design and prototyping of Traffic Bot and WAT – Web Archival Tool, its successor. Traffic Bot crawls websites known for ad postings for escort and massages services to collect data and then provides an interface to drill down the collected ad data based on phone numbers as a tool to identify potential cases of sex trafficking. Wang, et al. (2014) in designing the Traffic Bot framework examined how classified escort ads disguise phone numbers with the use of unusual punctuation and spelling and character or word substitution. They identified a regular expression method to be effective in detecting and decoding these phone numbers and used this technique as their filtering method. They were able to detect ads where the same phone number was listed for different women or multi-person services, two indicators of potential trafficking. They also note that by using the interface to drill down by phone number and identify instances where the area code differed from the location of the ad posting, one may be able to identify the location of a home base (Wang, et al., 2014). WAT – Web Archival Tool was geared specifically at identifying underage victims of sex trafficking (Hovy, et al., 2014). Hovy et al. (2014) clustered data collected via a daily web crawler of websites advertising escort services based on relationships between the postings themselves or poster of the ad. The system facilitated dynamic cluster movement as new data was added and provide three interfaces with which to analyze the resulting clusters (Hovy, et al., 2014).

These technologies are used to enhance KM and fit into KM/KMS as shown in Figure 1. Figure 1 shows that these technologies are used to construct filters that are used to convert data to information, knowledge, and actionable intelligence. Additionally, these filters assist users in generating sense making from the data, information, knowledge and actionable intelligence.

Indicators of Sex Trafficking in Ads

We reviewed the literature for research that focused on identifying victims of sex trafficking through indicators found in ads. We reviewed these indicators for those that we could operationalize through a set of key words/ontology. The below list and literature reflects those indicators that met this requirement.

Movement Between Cities

Ads that evidence frequent movement, or transience, may signal that a sex worker is a victim of trafficking. Pimps often move victims around from city to city in order to avoid law enforcement and to maintain control by keeping victims from building a social support system or becoming too familiar with a particular area (Dank et al., 2014). This movement also keeps victims disoriented and ignorant of where to seek help (Harris, 2012). However, pimps tend to move victims in groups or stables. Ultimately, this steady movement leaves women and girls consistently vulnerable to those who control them. Indeed, a study on trafficking in Silicon Valley found that traffickers often move sex workers around the Bay Area (Juniper Networks, 2014). The frequent movement between cities also has a marketing side. It serves to maintain a "fresh" product line for clients (Harris, 2012). In this way, traffickers constantly circulate "new product" to entice consumers (Ibanez & Suthers, 2014). They often move international women from the East to the West Coast, South to Northeast, and from urban to rural and vice versa. American women are trafficked across city and state borders and internationally (Raymond, Hughes, & Gomez, 2001). Additionally, traffickers may post ads in other cities to gauge the market in that area based on the amount of hits they get (Dank et al., 2014). By analyzing phone numbers posted in ads, researchers can identify area code networks in online escort service ads that can further identify patterns of victim movement in a geographical area (Ibanez and Suthers, 2014).

Ethnicity and National Origin

Ibanez and Suthers (2014) reference the denotation of ethnicity as a possible sign of trafficking. One needs to use this indicator in context of the dataset one analyzes before including it as an indicator to ensure that the dataset uses a variety of ethnicities/national origins because an estimated 72 percent of sex trafficking victims in California are American citizens. Thus, being "American" is not effective as an ethnicity or national origin term for identifying a potential trafficking victim.

Restricted Movement

Law enforcement officials believe that pimps consider it safer to conduct activities online and use incalls only (Dank et al., 2014). Previous studies have used restricted movement seen through terms such as "incalls only" as a possible indicator of sex trafficking (Ibanez & Suthers, 2014). To control their victims, perpetrators often deny them their freedom of movement and keep them isolated.

Unconventional Sex

One ad that researchers found to advertise a victim of sex trafficking included the term "open minded" (Operation Broken Silence, 2012), which may be a code word that signifies that customers can perform unconventional and sadistic types of sex. As such, an ad with such a phrase may increase the likelihood that the sex worker it advertises is a victim of trafficking (Yen, 2008).

Minors Trafficked Online

Sellers solicit buyers who are interested in purchasing young girls (often minors) using certain keywords that can indicate a sex trafficking victim. Ads for underage victims sometimes use words such as: fresh, fresh meat, young, virgin, prime, coochie (shaved), non-pro, new, new in town, barely legal/18, college student/girl, lovely, daddy's little girl, sweet, 1986 Firebird, new in the life, liked girls, youthful, and fantasy (Bouche, 2015; Boyd, Casteel, Thakor, & Johnson, 2011; Major, 2012).

Phone Numbers and Area Codes

Classified ads often include phone numbers. Customers and sellers sometimes use them to look up reviews on a particular girl and to see if the girl has alternate names (Ibanez & Suthers, 2014). Traffickers and victims often use multiple (both contract and disposable) phones in sex trafficking operations. Latonero et al. (2012) looked at the distribution of phone numbers using a simple Google search and found the phone number of one suspected victim on seven other escort service websites for multiple cities. Additionally, they found the same phone number on MyRedBook with a different name but similar photographs. This widespread advertisement across the Internet and geographic regions indicates more than just alone prostitute out to make extra money. It could even indicate a sex trafficking ring. Information from area codes strongly indicates the movement of victims and traffickers. The area code network offers both a source and destination. One can generate maps to determine suspected routes that sex traffickers use to transport victims from one location to another.

METHODOLOGY

System Development Method

We used the systems development research methodology from action research that Nunnamaker et al. (1990) and Burstein and Gregor (1999) describe. We chose this methodology in order to produce a system that combines technology with social understanding for detecting ads that offer the services of victims of human sex trafficking. The methodology uses a multimethodological conceptual approach that incorporates theory building, experimentation, and observation into systems building. System building is a form of applied research that focuses on solving a specific problem. Further, the system development method theory uses observation, and experimentation (or prototyping) methodologies to create the system. The system development method has five basic steps:

1. Identify and/or generate theory applicable to solving an information system (IS) problem. The system development method does not need to create this theory, but one can instead use it to design and build a prototype system to test or implement the theory in solving the IS problem (see second to fifth steps).
2. Create the concept for the proposed system.
3. Design and develop the proposed system.
4. Apply and use the proposed system.

5. Evaluate the success of the proposed system in meeting one's research question or goals.

In this study, we accomplished the first two steps using the literature review. Thus, in the first step, we identified and used the literature related to indicators of human sex trafficking in ads to create an initial ontology. In the second step, we identified and applied the KM concept of using a set of strong filters based on the ontology in a KMS designed to assess a dataset of ads. In the third step, we created the prototype by actually generating the ontology/keywords and identifying processes for obtaining a dataset, verifying the ontology/keywords against the dataset, and applying the ontology/keywords in order to analyze that dataset. In the fourth step, we applied the prototype that utilized the ontology/keywords and the processes that we created in the third step to assess a dataset for identifying victims of human sex trafficking. In step five, we evaluated the results from the fourth step and the proposed system to determine if the proposed system could accurately identify victims of human sex trafficking.

Literature Review Method

We identified the appropriate literature using the following search terms in various combinations: "sex trafficking", "human trafficking", "United States", "America", "California", "online", "Internet", "social media", "backpage", "craigslist", "classifieds", "ontology", "emojis", and "technology". We began the literature review using Google Scholar to find papers that have received a high number of citations and to establish a baseline of pertinent literature. We conducted further searches using databases such as Ebscohost-Academic Search Premier, Scribd, and JSTOR. We used papers' references that particularly related to this study to find other similarly related papers. Finally, we searched the *Journal of Human Trafficking*'s archives.

Interview Method

As follow up to the literature review, we conducted unstructured interviews with law enforcement and individuals involved in efforts to combat online human sex trafficking and with academic researchers with expertise in the area of technology and human trafficking. Specifically, we interviewed a San Diego County's Sheriff's Department sergeant who was a member of their joint-agency human trafficking task force and two University of Southern California faculty members involved in Department of Justice and Humanity United-funded research projects focused on creating a better understanding of the role of technology in human trafficking activities and the use of data analytics to combat sex trafficking. We selected these interview subjects based on their availability, and a single interviewer conducted them in order to avoid bias. The interviews consisted of two-open ended questions:

- Explain your main areas of research/methods for targeting and identifying online trafficking activities?
- How have you applied your knowledge of the language that traffickers use (ontologies) to efforts to combat or identify online sex trafficking activities?

Based on their responses, we asked the respondents to expand on certain areas that we deemed required a more detailed explanation. We intended these interviews to confirm the practical application of theory identified through the literature review and identify any additional knowledge areas the theory did not address. We identified several highlights. First, the human trafficking task force believes that an ad that features a sex worker as 25 years old or younger is most likely a minor. Second, the interviewees noted that one needs to consider the social implications in using technology to identify online human trafficking. Finally, they discussed the difficulty in distinguishing between trafficking and non-trafficking ads and the best approach to address this issue.

SYSTEM PROTOTYPE DEVELOPMENT

KM focuses on producing actionable intelligence. In this research, the actionable intelligence is the identification of ads that identify victims of human sex trafficking. To obtain this actionable intelligence, we created a KM strategy that used the system development methodology. This strategy required a system that applied strong filters to a large unstructured dataset of "women seeking men" ads to eliminate those from genuine individuals. We identified the "women looking for men" section of backpage.com from various southern California cities as our data source. The initial system prototype used an initial ontology of keywords generated from the human trafficking literature as strong filters to demonstrate that it could identify potential trafficking victims. We refined the prototype by using expertise to refine the ontology and by applying text mining/machine learning to verify the ontology of keywords and remove words that all or most ads included. Additionally, we identified that emojis were being used in lieu of or in addition to keywords. The emoji codes were added to the data analysis. We reapplied the refined ontology (keywords and emojis) as strong filters against a second unstructured dataset to demonstrate again that the system could identify trafficking victims from ads. Also as part of the strategy, we developed processes to extract an unstructured dataset and for applying the strong filters to the unstructured dataset to produce the desired actionable intelligence. In Sections 4.1 to 4.3, we describe how we created these strategy/prototype components.

Creating the Ontology/Keyword Set

To create an ontology/keyword set that could act as strong filters, we used a two-stage process with two different datasets. First, we used the keywords we identified (see Section 2.2) to identify which words from that list were in the first dataset. We extracted the keywords from each ad. To extract ethnic/nationality data, we used keywords in the filter feature of Microsoft Excel from both the text and title columns. We joined the Excel file to an area code location table to determine the origin of the phone number. We individually searched for area codes that the table did not represent online using Google. We used area code information to determine possible movement of providers. In all, 84 percent of the ads produced phone numbers, and we manually extracted another 12.6 percent because the ads disguised the phone numbers in some way. Ads often put random characters between numbers, write out the word, or use letters rather than numbers. Finally, 3.5 percent listed no phone number. We used the resulting list as the ontology/keyword set:

- Movement between cities included:
- Transient language: new in town, just arrived, visiting, in town for the weekend two nights only, new arrival, new arrived, brand new, limited time
- Group work: staff, ask for, my friend, sister, we, our, assistant
- Phone number, actual numbers from the dataset (used for three indicators: duplicate phone number, disguised phone number, out of state area code)
- Restrained movement: incalls only, incall only, only incall, no outcall, contains incall but does not contain outcall
- Minor indicators: little girl, youthful, sweet, young, college student girl, new in town, fresh, turned 18, only 18, fantasy
- Unconventional sex: open minded, fetish, kinky
- Ethnicity: White, Black, Asian, Islander, Caucasian, African American, Latina, Hispanic, mixed

After reflecting on the first ontology, we realized that the ontology would not be permanent and continue to evolve, especially when the traffickers realized what their words could identify trafficking victims (see Section 5.2.3). Thus, we decided to obtain a second dataset to verify the first stage ontology keyword set and to prototype applying the strong filters using R-based script. We verified the ontology keyword set from the first stage by applying experience from policing and research of human sex trafficking through unstructured interviews with human trafficking experts. Additionally, we used the text-mining module in R to parse the unstructured data to remove stop words and words that all or most ads included. The key issue was discriminating between keywords used in generic solicitations versus those used in marketing victims of human sex trafficking. The impact of these actions resulted in the 9 indicators in the initial ontology being reduced to 6 indicators for the revised ontology. The final ontology is:

- Sale of services: donation(s), price, rose(s), dollar(s), jacks, jacksons, hundreds • Minor victims: fresh, young, new, tiny, little, new in town, girl, college
- Ethnicity:
- African American: AA, African American, Brown Sugar, Black (Beauty)
- Asian/Pacific Islander: Pocahontas, Asian, Pacific Islander
- Caucasian: Caucasian, White, European
- Latina: Latina, Hispanic
- Country of origin/nationality: South/East Asia, Eastern/Western Europe, Central America

Transient activity/movement of victims: new in town, just arrived, weekend only, limited time, new arrival, brand new, in town for the weekend, gone, back, leaving soon, only for the weekend, new

- Non-independent worker/restricted movement: incall only, no outcall, only incalls, come to me, my house

Also while analyzing the second dataset it was noted that there were emojis in the text and that in many cases the emojis seemed to occur with human sex trafficking keywords. The evaluation of emoji indicators also involved the use of the tm package in R to build a Term-Document matrix with the corpus of ads with each emoji indicator. In order to create a framework for filtering out terms in ads that are not likely to be related to human trafficking, we identified the terms that occurred most frequently across all documents in the corpus to remove from the corpus before analysis. To do this the Term-Document matrix was used to remove sparse terms and then identify the most frequently occurring terms as they are less likely to be specific to human trafficking. These words were selected by identifying not only at the most common terms within the corpus, but also the terms that were present in ads without any indicators of human trafficking. Words common in both these elements were identified as being part of the general ontology for any classified ads related to the provision of sexual services or casual dating and not specific to sex trafficking. For validation of these results, the study looked not only at the most common terms within the corpus, but also the terms that were present in the majority of the documents.

A knowledge management approach was then used to identify emojis in ads likely to be linked to human sex trafficking. Clusters of ads with and without keywords associated with human sex trafficking indicators were built by applying natural language processing methods to the unstructured dataset. These clusters then determined the frequency of the emoji occurring in each cluster. Ad significance was then determined through logistic regression analysis and t and z tests.

Process for Extracting the Unstructured Dataset

We created the first unstructured dataset by scraping Web advertisements from websites known to post sexually explicit solicitations/ads. To make it usable for analysis, we converted the scraped data into a .csv file then manually processed into a Microsoft Excel file for analysis.

After reflection, we obtained the first dataset mostly through a manual process, which we considered unsustainable for an automated system approach, so we decided to create a second dataset to test the revised ontology. As such, we created an automatic Web-scraping tool with various approaches. However, this method did not work well because the target websites blocked automatic Web scraping. As a result, we scrapped the automated Web scraping and repeated the manual process to obtain a .csv file with the raw data. We then processed the raw data file using Excel to remove duplicate postings (in this study, we analyzed content and not frequency, so multiple postings would bias the results) and to identify records with missing data. We loaded the resulting processed raw data file into R's machine-learning and text-mining functions to remove stop words contained in the English stop word dictionary and to identify words common to all ads.

Process for Applying the Prototype

We developed a simple process that involved actual keyword counts to apply the ontology/keyword set to the unstructured dataset. We used count functions in Microsoft Excel to generate the number of times keywords appeared and to determine if an ad contained a trafficking indicator. We also used other mathematical functions in Microsoft Excel to generate results such as the percentage of ads that contained the keyword.

After reflection, we modified this process for the second prototype. Instead of using Excel to do word counts, we used R to code each add with a series of 0 or 1 codes. R coded each human trafficking victim indicator 0 if an ad contained no ontology/key word indicators or 1 if an ad did contain ontology/keyword indicators.

R then summed the number of victim ontology/keyword indicators for each add. By using R to code the dataset, we could automate the analysis portion of the prototype.

APPLYING THE PROTOTYPE

Creating the Dataset

The first application of the prototype used a dataset that we extracted from backpage.com for several cities in California. We chose California because we live in the state and because it is a major hub for prostitution and sex trafficking. California encompasses many ports of entry and lies adjacent to the Mexican border region, which is rife with human trafficking (Goldenberg, et al., 2014).

We gathered data for the study by scraping from the "female escort" section of backpage.com from 11 to 16 February, 2015, across 15 different California cities/counties: Bakersfield, Chico, Fresno, Los Angeles,

Merced, Oakland, Orange County, Sacramento, San Diego, San Francisco, San Jose, San Luis Obispo, Santa Barbara, Santa Cruz, and Stockton. Some errors occurred in the data-scraping process. San Diego only produced about two-and-a-half days of data due to an error, so the data sample for that city was smaller than that for the other large cities. In total, we scraped a total of 5,633 ads. We then processed the data was as we discuss in Section 4.2.

After reflecting on the first dataset, we collected the second dataset from the "women seeking men" section of the dating classifieds on backpage.com. The sample included advertisements posted between February and March, 2017, for three major cities/counties in Southern California: San Diego, Los Angeles, and Orange County. We selected this sample because of the close proximity of the three cities, which makes the language used in the advertisements subject to less variability due to regional language differences. The initial dataset included 8,940 records that we processed in accordance with Section 4.2; as a result, 8,744 records remained in the final dataset.

ANALYZING THE DATASET

Analyzing the First Dataset Using the Initial Prototype

We analyzed the first dataset as we discuss in Section 4.3. Specifically, we compiled keywords that indicate possible minor sex trafficking and analyzed them against the advertised age. We combined all ages past 30 into one group as the large majority of ages were between 20 and 25. Note that the advertised ages are not necessarily accurate, especially in trafficking situations. Traffickers may be more likely to advertise a victim of minor sex trafficking as being aged from 20 to 25—young enough to still attract the correct buyer but old enough not to raise law enforcement suspicion. Overall, we found a number of prominent age terms such as “sweet”, “young”, and “fantasy”; rarer terms included “only 18”, “turned 18”, “very young”, and “little girl”. Traffickers would not likely use the rarely used keywords for fear of attracting law enforcement. Additionally, terms such as “college student/girl”, “new in town”, and “fresh”, seem to skew slightly toward younger ages, which could indicate younger individuals.

Many ads had multiple keywords. Out of the sample of 5,633 ads, 4,836 had a least one indicator of human sex trafficking. By far the most prominent indicator was “duplicate phone/ad”. These results are similar to those that Latonero et al. (2012) found. Specifically, these authors found that a small number of phone numbers accounted for a disproportionate amount of ads; however, on reflection, we believe that this disproportion reflects people’s practice of keeping their mobile number even after moving and provides little information with respect to victims of human sex trafficking. As such, we can conclude that a single indicator of human sex trafficking cannot sufficiently identify a potential victim and that duplicate phone/ad by itself does not provide enough discerning information to identify a victim of human sex trafficking but that it is likely to be a good indicator in combination with other indicators. The following list includes the percentage of total ads with the specified indicator present:

- Duplicate ad/phone number (54.8%)
- Ethnicity/national origin (44.9%)
- Unconventional sex (13.4%)
- Disguised phone number (12.5%)
- Out of state area code (12.1%)
- Restriction on movement (11.8%)
- Transient language (9.0%)
- Indications of working in a group (8.8%)
- Minor keyword indicators (5.2%)

The following list shows how many ads had multiple indicators (out of nine indicators):

- 4,836 had at least one indicator
- 3,126 had at least two indicators
- 1,354 had at least three indicators

- 330 had at least four indicators
- 74 had at least five indicators
- Eight had at least six indicators
- One had seven indicators.

Analyzing the Second Dataset Using the Revised Prototype

We analyzed the second dataset as we discuss in Section 4.3.

The following list shows percentage of ads with the indicated keyword indicator:

- Sales of service (1.56%)
- Minor (48.2%)
  Ethnicity (30.3%)
- Country of origin (11.4%)
- Transient language (12.67%)
- Restriction of movement (0.71%)

The following list shows how many ads had multiple indicators (out of 6 indicators):

- 3,534 ads had at least one indicator
- 1,768 ads had at least two indicators
- 467 ads had at least three indicators
- 33 ads had at least four indicators
- Two ads had five indicators

To compare the ontology to the emojis the subset function in R was used to create two populations of ads, one with known indicators of trafficking and the second without indicators of trafficking. These known indicators consisted of keywords/ phrases in the ontology used. The indicators of human sex trafficking are: sale of services, minor/underage victims, ethnicity/race, country of origin, transient activity/ movement of victims, and non-independent workers/ restricted movement.

Ontology development identified: (Note that ethnicity and country of origin emojis are common across all ads and no special emojis were found specific to human sex trafficking)

- Two emojis: the rose and the rosette for the keyword indicator of sale of services.
- Three emojis: the growing heart emoji, cherry emoji, and cherry blossom emoji for the minor keyword indicator

- One emoji, the airplane emoji was the only significant indicator for the keyword indicator of transient activity
- One emoji, the crown emoji was found significant for keywords associated with restricted movement/non-independent.

The following list shows how many ads had multiple emoji indicators:

- 2,237 ads had at least one indicator
- 790 ads had at least two indicators
- 216 ads had at least three indicators
- 36 ads had at least four indicators.

Finally, looking at both keywords and emojis we get the following list having multiple indicators

- 1,825 ads had at least three indicators
- 509 ads had at least four indicators
- 127 ads had at least five indicators
- 37 ads had at least six indicators.

Discussion

It is shown that keywords and emojis can be used as indicators of sex trafficking. It is observed that the number of ads with multiple indicators dropped quickly the more indicators that were identified. This was an expected result that illustrates that the process works. Comparing the number of ads with multiple indicators to the 792 reported cases of human sex trafficking in California in 2015 (NHTRC, 2016) and 544 human sex trafficking cases in the first half of 2017 (Polaris Project, 2017) suggests that one can establish a threshold number of indicators that indicates a possible sex trafficking victim. The first dataset suggests either four or five indicators as the threshold (out of nine indicators). Four is a conservative threshold that will not likely miss any victims but will probably include many false positives on potential victims because, in the sample, 330 ads had four indicators (about 40% of the yearly number of reported sex trafficking cases). Using five or more indicators strongly suggests a victim of sex trafficking: in our sample, five or more indicators yielded 74 potential victims (or 9.3% of the yearly number of reported sex trafficking cases). Given the limited resources available to law enforcement, a more focused number, although it may miss some potential victims, may be better. This logic suggests that four indicators (out of six) in the second dataset as the threshold because 33 ads is about six percent of the 544 cases reported in the first half of 2017. Finally, if using a full ontology including emojis and keywords it is recommended that a threshold of 6 indicators (either emoji or keyword) be used. To sum up, it is recommended that five indicators (when one uses nine indicators total), or four (if one uses six indicators in total), or 6 indicators (if using emojis and keywords) be used as a threshold for recommending law enforcement intervention.

We also observed that, while phone-based indicators seemed to be useful in the first dataset, we removed them from the revised ontology for the second dataset. We removed duplicated phone numbers as an indicator because this indicator did not discriminate between trafficking phone use and regular prostitution phone use well enough. We dropped the other phone indicators (i.e., blocked or disguised phone numbers or out of area phone numbers) because it is becoming too common of a practice to usefully serve as an indicator (i.e., many people now commonly block or disguise their phone number for privacy and security reasons, and carriers now commonly allow customers to keep their phone numbers when they relocate). Conversely, we have a concern that the indicators do not do a good enough job discriminating between voluntary prostitution and sex trafficking victims. Ethnicity and to a lesser degree country of origin and minor indicators (especially in the second dataset) do not discriminate between sex trafficking victims and voluntary prostitution and only work in conjunction with other indicators, which strengthens the argument for using at least four (when using six in total) or five (when using nine in total) indicators for initiating follow-up actions.

We used backpage.com for this research as a case study, but it only accounts for a portion of all online escort ads. We created a prototype that can be implemented into various websites. The difficulty in using it rests in the data-extraction process as we observed when we attempted to use craigslist.com. It may be possible to use the data-extraction process only when generating/validating the ontology and using the analysis process as a constant online monitoring and alarm tool.

EVALUATING THE PROTOTYPE

The prototype was evaluated by reflecting on the outcomes generated when applying the prototype to a real dataset. As a result, a revised dataset was created and tested. Reflection on these results when compared to outside reports on the numbers of human sex trafficking victims resulted in the recommended thresholds (see Section 5.2.3) to use to identify potential victims of human sex trafficking. Additionally, the system development methodology includes a five-step evaluation process (Burstein & Gregor, 1999) for assessing the quality of the system development methodology process. This assessment is described below. Overall, it is noted that the proposed prototype is acceptable as an output of the system development methodology as it met all steps of the five-step evaluation process.

Significance

Outcomes/artifacts from the system development research methodology should yield significant theoretical contributions, a system that yields better results than those systems currently in use, or both. In our case, we created the latter—a significant practical contribution that yields better results than the ones that currently exist.

Currently, law enforcement agencies search adult service classified ads to find to find pictures of people that look as though they are being trafficked (Latonero et al., 2012). Commonly, law enforcement agencies begin investigating possible sex trafficking by browsing through ads and looking for girls with pictures that look very young. If the girl looks underage, they may open an investigation (Latonero, 2011). They also compare an advertisement's picture with the advertised age. If they perceive a discrepancy between a girl's picture and her advertised age, law enforcement agencies may also open an investigation. Although these techniques have been one way to locate potential victims, they suffer from complications. First, it is extremely tedious and, second, photos are not always accurate (Latonero, 2011). While many law enforcement agencies use these tactics with some success, the system proposed in this chapter may identify more potential victims without generating large numbers of false positives. It is evaluated that the proposed ontology/system has practical significance.

Internal Validity

Internal validity refers to the credibility of one's results and whether they make sense. Established theory was used to generate an ontology that was applied to an unstructured dataset with the results presented in this chapter. The presented results are consistent and expected given the theory used and its application to the problem.

Further, to verify internal validity, rival methods were considered. Other work that has investigated this research area was reviewed, but it has all used some form of ontology-based method for identifying potential victims. For instance, Ibanez and Suthers (2014) used escort advertisement data to evaluate the significance of known indicators of online trafficking activity. They found that ads that contain two or more indicators are more likely to be instances of trafficking and that the most prevalent indicators for trafficking in order are ethnicity/nationality, potential restricted movement, movement along trafficking circuit, and shared management (multiple providers). Dubrawski, Miller, Barnes, Boecking, and Kennedy (2015) trained multiple random forest models using three different information-extraction approaches, term frequency analysis using law enforcement provided keywords, regular expressions, and machine learning to weight 115 keywords. Alvari, Shakaria, and Snyder (2016) used a sample advertisements posted on backpage.com in March, 2016, to train a learning classifier. They used a semi-supervised learning algorithm to label the remaining advertisements and had experts in online sex trafficking review the classifications to evaluate accuracy. Considering Alvari et al. (2016), natural language processes and text mining in the prototype were added for the second dataset.

External Validity

External validity concerns "the generalizability of a causal relationship to and across populations or persons, settings, and times" (Burstein & Gregor, 1999, p. 134). To test external validity, the developed prototype was applied across a variety of nationalities and ethnicities but all in the state of California. It is conceded that the prototype can be applied to any population/ad sample in the United States, but it may not be generalizable directly to other cultures. We do believe the indicators are applicable for other cultures and countries, but would need to adjust the ontology to fit their language(s)/culture(s). Using the AI and machine learning approaches incorporated into the second prototype provides a means for identifying and adjusting indicator terms based on language and culture differences. Thus, it is noted that the revised prototype has external validity for the United States and has external validity for other cultures/countries when one adjusts the prototype processes for culture/country.

Objectivity/Confirmability

Objectivity/confirmability concerns ensuring research does not suffer from researcher bias or that the researcher at least reports and discusses them. By basing the indicators on the literature and then generating the ontology by using the words in the extracted data, we removed much of our own bias for our prototype. Further, we used machine learning and text mining in the revised prototype to further reduce it.

Reliability/Dependability/Auditability

Reliability/dependability/auditability concerns quality control. The system was developed using a process that is consistent and stable across researchers and methods. We relied on the literature and the accepted system development research methodology to generate the prototype. Thus, it is concluded the prototype has sufficient reliability, dependability, and auditability.

CONCLUSION

It is concluded that the prototype works and that it deserves further development. We found that the prototype meets the requirements of the system development methodology from action research and that it yields promising results when tested against actual datasets. We also recommend that an alert/warning system be developed based on this research that can provide a warning when ads contain five or more indicators (when using the nine ontology), four or more indicators (when using the six ontology), or six or more indicators (when using emojis and keywords)—thresholds determined based on comparing the number of ads the indicators identified with the number of reported victims (i.e., 792 for the first dataset (NHTRC, 2016) and 544 for the second dataset (Polaris Project, 2017)). We expect the suggest alarm system to result in a low number of positive alarms.

Further, we conclude that the system development method, especially when used with KM driven machine learning, is a viable approach to conducting research into developing systems to solve social problems. We found the method very useful for taking the emphasis off the application of new technologies and keeping the research focused on solving a social problem and building a system to do so.

IMPLICATIONS FOR RESEARCH

The initial prototype is a proof of concept, while the revised prototype moves towards an automated system; however, neither creates any new theory. Research focused on integrating more advanced technologies into a KM system for generating actionable intelligence that authorities can act on could generate significant social benefit. Specifically, we need future research that further focuses on automating the prototype's data-extraction process. A framework for developing the full automated system should be developed based on this research and the framework presented in Jennex (2017a, 2017b), a proposed KM model based on a modified knowledge pyramid and the revised Jennex-Olfman KM Success Model.

IMPLICATIONS FOR PRACTICE

Finding victims of human sex trafficking is difficult and requires all the technology innovation possible. The practice of using posted photos and facial recognition is not working well and needs improvement. This study suggests how technology in practice can be used to identify victims of sex trafficking. Practitioners will need to adapt to the processes that we illustrate in the paper and to adapt their intelligence gathering and investigative techniques to take advantage of the technology we prototyped.

LIMITATIONS

This study has two major limitations. First, only female victims were considered. While we recognize that males can also be victims of human sex trafficking, males were not included in the study because we sought only to demonstrate that a KMS could be used to identify victims and considering males made the project more complex than needed.

Second, we cannot prove conclusively that the potentially identified victims were in fact real victims. Given ethical concerns with the research, we could not actively interview rescued victims or actively search for victims.

Both limitations may impact the generalizability of the proposed system but are considered acceptable for this research.

AREAS OF FUTURE RESEARCH

Researchers could extend our findings by investigating at least two areas. First, researchers could examine male victims to determine if the indicators and keywords differ from female victims. Second, they could investigate technologies that can be used to create an automated KMS. We used Excel to conveniently demonstrate a proof of concept in the initial prototype. The second prototype incorporated text mining and machine learning to assist in automatically generate an ontology and analyze data. Thus, our approach experienced weaknesses in extracting data, and future research needs to develop and automate the data-extraction process.

Additionally, data from online adult service ads can be used to inform the study of the commercial sex industry and, consequently, sex trafficking. The data we gathered shows indications of the geographic trafficking patterns across state borders and the demographic makeup of many individuals. This information can help identify previously unknown trends in sex trafficking.

ACKNOWLEDGMENTS

Earlier versions of this research were presented at the 49th and 51st Hawaii International Conferences on Systems Sciences, HICSS, in January 2016 and 2018. Additionally,

a journal article version of this paper without addressing emojis was published in Communications of the Association of Information Systems in 2018.

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