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Managing Operations Throughout Global Supply Chains

Jean C. Essila

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Managing Operations Throughout Global Supply Chains

Jean C. Essila
Northern Michigan University, USA

A volume in the Advances in Logistics, Operations, and Management Science (ALOMS) Book Series

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Businesses around the world experience many challenges to acquire raw materials, parts, subassemblies, and the other necessary inputs to their production systems. As businesses are all moving into the e-commerce platform to gain market share, they realize that electronic supply chain management (e-SCM) powered by enterprise resource planning systems (ERPs) are the new norms and no business organization can operate without both in the new world of e-commerce. Little attention has been devoted to e-SCM dynamic with ERP and the challenges they pose to organizations. In the e-commerce environment, e-SCM is among the most important factors to organizational success. Effective e-SCM can enhance competitiveness and increase market share leading a higher profitability. Nevertheless, the new e-SCM professionals and other actors must understand the factors that undergird e-SCM performance, their drivers, and the necessity of fully functional ERPs for an effective e-SCM.

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Framework for Measuring the Performance of Production Operations in the Dairy Industry 20
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For the business operations in the dairy industry, the quick, safe, and hygienic production processes are of crucial importance. The chapter is aimed to develop a framework for evaluating the performance of production operations in dairy industry. An optimum production model is developed through factor analysis and structural equation modelling (SEM) methods applied to the responses collected from different dairy industries. The hypotheses testing suggests that all five factors positively affect the production operations of dairy supply chain. The outcome of the study reveals that the dairy industry needs significant improvement in their production operations to attain competitiveness. Further, this study is helpful for the dairy industry in handling the demand fluctuation, execution of effective production and information systems, improved product quality, process flexibility, etc.

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In recent years, growing market competition has made companies increasingly dependent on their suppliers, which requires effective management of their supply chains. To establish and maintain relationships with the best suppliers, companies apply strategic supplier selection, evaluation, and development criteria. The literature review showed the importance of supply chains and the use of strategic criteria in managing relationships with suppliers. Based on the model proposed by Oflac, the authors studied a local subsidiary of a global company of components for the automotive industry. Through this case study, it was possible to understand how a firm establishes strategies and performs in the practice its supply relationship management activities. Results suggest that the existence of strong and continuous relationships creates advantages for companies, allowing them to remain competitive in the markets. The strategies of selection, evaluation, and development of suppliers enable companies to filter the best partners and develop their capabilities to achieve greater profits.

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As the supply chains become more global, the operations (such as procurement, production, warehousing, sales, and forecasting) must be managed with consideration of the global factors. International trade is one of these factors affecting the global supply chain operations. Estimating the future trade volumes of certain products for specific markets can help companies to adjust their own global supply chain operations and strategies. However, in today's competitive and complex global supply chain environments, making accurate forecasts has become significantly difficult. In this chapter, the authors present a novel big data analytics methodology to accurately forecast international trade volumes between countries for specific products. The methodology uses various open data sources and employs random forest and artificial neural networks. To demonstrate the effectiveness of their proposed methodology, the authors present a case study of forecasting the export volume of refrigerators and freezers from Turkey to United Kingdom. The results showed that the proposed methodology provides effective forecasts.

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Hong Kong's Innovation and Technology Fund (ITF) from the Hong Kong Special Administrative Region's Government supports collaborative R&D projects in industry, academia, and research centers. This chapter has been developed for the ITF project teams and collaborative organizations specifically, but it is a useful reference for project teams working with multiple partners or stakeholders. This chapter is the result of the author's Engineering Doctorate research on "Enhancing the Commercialization Success of Innovation and Technology Fund (ITF) R&D Projects in Hong Kong's Logistics and Supply Chain Industry." It takes the readers through the process from project identification to commercialization. The process described in the chapter has been effectively implemented in a recent ITF project in Hong Kong's logistics and supply chain industry. The chapter is a useful standard operations procedure (SOP) for collaborative R&D project teams.

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and multiple-regression tests were used to eliminate some ratios, and to find a combination of 12 ratios that successfully account for 35% of the variability in stock prices. The results point to leading indicators, statistically significant ratios, and a predictive model for forecasting stock price.

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In today's competitive environment, agile firms tend to be more successful. If today's technology companies, which are leaders in their sector, may fail in that competitive environment, it would be possible that they might lose their market leadership in the future. Some companies which were in the top in market in their own sector in the past are likely to be stand back from their competitors for not adapting to market change conditions. Fast process of technology and digital world are taking place in all organizational authoritative in all area and in all kind of sectors because the business world is transformed by the postmodern revolution-Fourth Industrial Revolution. In this dynamic environment, leaders should learn new management behaviors, with which they can communicate both internal and external environment of their enterprises by the strategies of being agile and innovative organizations. This can be by being aware of changes in environment and having the ability to manage these changes for the company's favor.

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During the early 2000s, the advent of internet and e-communication enabled organizations to be more responsive and cater to their customers' needs in a better way. Over the last few years, integrated technologies and ERP systems has allowed organizations to gain market share and establish themselves as e-commerce players. This has been achieved through better synchronization, business realignment, and operational flexibility. The rapid development in fields of information technology has transformed old partnerships between suppliers, buyers, and service providers into a more collaborative business process where information and knowledge sharing is a key success parameter. Through enhanced IT capabilities, SMEs can cooperate to form a network and promote their joint capacities to acquire a complex project and integrate resources for a better planning and execution. In this chapter, the author seeks to highlight the importance for e-SCM to be implemented and adopted, current status of adoption through case studies, benefits of e-SCM as strategy and challenges plaguing adoption of e-SCM.

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This chapter aims to explain system dynamics approach. System dynamics approach was developed by Jay Forrester from MIT during the 1950s to analyze especially the complex behavior in administration with computer simulation in social sciences. System dynamics is a form of systems approach as a methodology to understand the dynamic behavior of complex systems. The basis of system dynamics is to understand how system structures cause system behavior and system events. System dynamics deals with how things change over time. Almost all are interested in how the past formed the present moment and how today's actions determine the future.

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Within the agricultural sector, it becomes essential worldwide to analyze the magnitude of OHS problems. However, there is a lack of study in Odisha (India) to assess the prevailing situations. Hence, an attempt was made in this study to explore the issues related to OHS among the farmers of Odisha in India. There is a dual main contribution in this study. At first the occupational health and safety issues of

farmers of Odisha in India were analyzed based on the literature review and the data collected by personal interaction and questionnaires. In the second part, the step-wise weight assessment ratio analysis (SWARA) method was used to rank the different farming processes, as well as different risks involved in various farming activities.

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Suchismita Satapathy, KIIT University, India

All companies are dependent on their raw material providers. The same applies in the case of thermal power plants. The major raw material for a thermal power plant is the coal. There are a lot of companies which in turn provide this coal to the thermal power plant. Some of these companies are international; some are local, whereas the others are localized. The thermal power plants look into all the aspects of the coal providing company, before settling down for a deal. Some people are specifically assigned to the task of managing the supply chain. The main motive is to optimize the whole process and achieve higher efficiency. There are a lot of things which a thermal power plant looks into before finalizing a deal, such as the price, quality of goods, etc. Thus, it is very important for the raw material providers to understand each and every aspect of the demands of the thermal power plant. A combination of three methods—Delphi, SWARA, and modified SWARA—has been applied to a list of factors, which has later been ranked according to the weight and other relevant calculations.

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Research on sustainable supply chain management (SSCM) has been garnering interest because of its multi-approach in nature. SSCM has emerged as an essential method for organizations to develop and to enhance their competitive strategy through innovative ways in order to satisfy customer basic needs. It facilitates competitive advantage, faster flow of information, material, less response time, speeding up delivery action, better relation and coordination among partners, easy way of information sharing, and increasing order fulfilment rate. Implementing SSCM in organizations like thermal power plants has other benefits such as increasing attention about environmental performance intending the integration of social as well as economic performance. In this chapter, the artificial neural network (ANN) method is used to measure the customer satisfaction after implementing SSCM by thermal power industries.

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Jean C. Essila, Northern Michigan University, USA

Job shop manufacturing processes have been reluctant to adopt enterprise resource planning systems (ERPs) for enhancing logistics performance. The cost of adopting and deploying ERPs is a high-entry barrier. Prior research has claimed that performance can be enhanced by improving logistics planning using technology such as ERPs. Most past research has examined the effect of ERPs on logistics performance in production processes other than job shops, which seems to suggest that in small-scale production processes the cost of ERPs makes it irrelevant. Are manufacturing job shop production processes the exception that proves the rule? Using both a t-test two sample for means and a Kolmogorov-Simonov (KS) test, this study tested whether or not ERPs can improve supply chain logistics performance in job shop manufacturing processes. The results might lead to a positive social change in the adoption or non-adoption of ERPs in job shop manufacturing.

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Preface

That 440 of the 500 *Fortune* firms have closed their doors must be a wakeup call for all of us. Yes, only 60 of the Fortune 500 companies in 1955's *Fortune* ranking are still in operation today. "In other words, fewer than 12 percent of the *Fortune 500* companies included in 1955 were still on the list 62 years later in 2017, and 88 percent of the companies from 1955 have gone bankrupt" (Perry, 2017). That nearly nine out of ten of 1955's Fortune 500 companies are gone is disturbing and calls for a deeper analysis of what business schools teach their graduates and how they contribute to business success or failure. This represents an 88 percent failure rate. The probability that an organization in business today will still be in business in twenty years is only 12 percent. With this knowledge in mind, I realized, while working as a consultant with various companies, that enough attention is not devoted to supply chain management. I asked myself, "As business school professors, should we continue to teach the same way, or should we try new approaches to teaching business management, including how to manage operations across supply chains in a global economy?". The result was the idea to publish a reference book in the field with contributing authors from all over the world.

However, business school professors alone are not the solution to the problem. I have observed graduates choose to ignore operations management principles and models and run operations using their best guesses. This situation often results in high operating costs. Businesses need strategic leaders, who can critically think, envision a valuable and sustainable future for their organization, and work well with and through other people to achieve common goals and transform the world for the better. My conversation with many business leaders has helped me understand another root cause of the problem. Although Lardner's Law, also known as the Law of Squares, states that any reduction in transportation costs will be directly proportional to the increase in the market area where the product can be sold, most business leaders do not understand to what extent supply chain management matters. The rationale has often been that if you want to increase profit, you have to master finance principles and apply them. Business leaders tend to forget that transportation is the largest logistics cost. Today's reality is hard to accept: Our ordinary solutions to business problems are not effective. Business organizations are facing extraordinary challenges that necessitate extraordinary solutions. As businesses become globally sensitive entities, supply chain management becomes the most important matter because all companies along the supply chain are important to business success or failure (Gruchmann et al., 2019). In addition, I have observed graduates who chose to ignore operations management principles and models and decided to run operations using their best guesses. This situation often results in high operating costs, making strategic operations reviews the new norm.

Have you ever wondered why today's richest person in the world is Jeff Bezos, Amazon's CEO, and not a banker? The speed at which Jeff Bezos became the richest person loudly speaks to the power of supply chain management. Organizations are becoming supply chain dependent, so companies that do not have mastery of their supply chain dimension will disappear from the business landscape (Essila, 2018). Analysis shows that the 440 companies from Fortune's 1955 list that failed and disappeared all had weak supply chain management in common. Their leaders neglected the supply chain dimension. The current closing of many retailers indicates the necessity of adapting to the new norm. Yes, sadly, American retailers have already announced the closure of 6,000 stores in this year (2019) alone! A supply chain is now the important factor for business success or failure (Ali & Haseeb, 2019). First, it is important to understand how the business operations management field has evolved over time.

Operations management can be traced back to 2630 BCE with the construction of the Egyptian pyramids (George, 1972; Robbins & Coulter, 2012). During that process, individuals were in charge of planning, organizing, leading, and controlling operations and other people's various work activities. Another example is the 13,000-mile Great Wall of China built between 220 and 206 BCE to protect the Chinese empire. This complex project likely involved more than 100,000 workers and took twenty years to be complete. Construction of the city of Venice is another example of operations and project management practice. According to Robbins and Coulter (2012), the first published research on management was Adam Smith's 1776 book *The Wealth of Nations*. Smith promoted the economic advantages that organizations and nations could gain by using division of labor, also known as job specialization. Operations and supply chain management are job specialization areas within an organization. The Industrial Revolution, which began in 1750, followed. Innovative technology such as machine power, substituted for human power, increased productivity. Production moved from homes to factories. Frederick Winslow Taylor published *The Principles of Scientific Management* in 1911, emphasizing the importance of operations management using analytical methods to improve operational efficiency (Stevenson, 2018). New technologies triggered the emergence of large factories that needed people who could efficiently forecast the demand for goods and plan for their distribution. However, formal theories were needed to guide managers in running the new large organizations (factories) generated by the new technology. These individuals were named operations managers.

Today, new concepts such as *self-thinking supply chain* (Calatayud, Mangan, & Christopher, 2019) and *digital supply chain control tower* (Crandall, 2019) are shaping the new ecommerce environment powered by electronic supply chain management (e-SCM). A new group of supply chain professionals has emerged called e-logistics experts. Supply chain management connects suppliers and customers through its logistics component. Each supply chain echelon adds value through its operations such as unloading, inspecting, sorting, stocking, or reloading products to get closer to the end user. Supply chain challenges include outsourcing to or sourcing from other countries with various cultures. Strategic operations review is becoming a standard procedure to achieve a competitive advantage in today's global market. Therefore, it is important to understand the co-specialization relationship between product modularity and supply chain agility and how it relates to organizational performance (Saeed, Malhatra, & Abdinnour, 2019).

This book, *Managing Operations Throughout Global Supply Chains*, presents the latest concepts in the operations and supply chain field, as well as modern operations' manufacturing techniques and technologies. The concepts of operations and supply chains have evolved over time. Operations management discipline includes the design, development, implementation, and monitoring of processes that create goods or enable the provision of services in a cost-efficient manner. The production of goods or services requires such inputs as raw materials, labor, technology, finance, and intellectual capital. The concept of supply chain management emerged to help organizations manage the procurement of all necessary resources at every stage of the production cycle from the original source to the final consumers. The two concepts merged to form a system that requires careful planning and coordination of activities at various facilities. Globalization has made both operations and supply chains more complex than ever before. Inputs are sourced from many locations around the world to serve different needs and market segments throughout the planet, making it a global challenge that necessitates a global strategic response.

This reference book attempts to set the stage for discussing concepts, methodologies, and applications of techniques in an ever-changing and challenging discipline. It is designed to be an advanced academic publication for researchers and academicians, and a reference source in the field of operations and supply chain management that allows researchers to easily identify concepts, methodologies, and literature reviews for citations and critically set the stage for discussing their research project results. Practitioners may also use the book as a repertoire for the application of methods and concepts. Topics include, but are not limited to, productivity; strategic capacity planning; product, service, and process design; process management; quality and supply chain management; global supply chains; global operations management; material requirement planning (MRP); enterprise resource planning (ERP) and electronic supply chains; just in time (JIT); inventory control; project management; Six Sigma; and lean production. The book includes fourteen chapters that discuss the close-loop of operations and supply chains that results from planning, organizing, leading, and controlling operations across global supply chains. Its target audience includes researchers and academicians, practitioners, institutions of higher education, professional organizations and associations, policy makers, and governments (local, state, and federal). It can also be used for library reference section inclusion or course supplementary materials in upper-level classrooms.

Global supply chains face many challenges. Logistics must optimize two conflicting objectives: meeting and exceeding customers' needs and minimizing total system costs for a greater return on investment and business sustainability. Mathematical modeling requires matching demand and supply in the environment set for its failure. The ever-changing business environment is full of uncertainty and asymmetry, making it almost impossible to predict. Therefore, planning becomes imperative because failing to plan is planning to fail. Planning operations, along with pre- and post-supply chain activities, are at the core of today's operations system.

ORGANIZATION OF THE BOOK

The book includes 14 standalone chapters. A brief summary of each follows.

Chapter 1: The Role of Electronic Supply Chains and ERP Systems in the Realm of E-Commerce

Businesses around the world experience many challenges to acquire raw materials, parts, subassemblies, and the other necessary inputs to their production systems. As all businesses move into the e-commerce platform to gain market shares, they are realizing that electronic supply chain management (e-SCM), powered by enterprise resource planning systems (ERPs), is the new norm and no business organization can operate without it in the new world of e-commerce. Little attention has been devoted to the e-SCM dynamic with ERP and the challenges they pose to organizations. In the e-commerce environment, e-SCM is one of the most important factors to organizational success. Effective e-SCM can enhance competitiveness and increase market share, leading to higher profitability. Nevertheless, the new e-SCM professionals and other actors must understand the factors that undergird e-SCM performance, their drivers, and the necessity of fully functional ERPs for an effective e-SCM.

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For business operations in the dairy industry, the quick, safe, and hygienic production processes are of crucial importance. The current chapter is aimed at developing a framework for evaluating the performance of production operations in the dairy industry. An optimum production model is developed through factor analysis and structural equation modeling (SEM) methods applied to the responses collected from different branches of the dairy industry. The hypotheses testing suggests that all five factors positively affect the production operations of the dairy supply chain. The study's outcome reveals that the dairy industry needs significant improvement in its production operations to attain competitiveness. Further, this study can be helpful to the dairy industry in handling demand fluctuation, executing effective production and an effective information system, improving product quality, processing flexibility, etc.

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In recent years, growing market competition has made companies increasingly dependent on their suppliers, which requires effective management of their supply chains. To establish and maintain relationships with the best suppliers, companies apply strategic supplier selection, evaluation, and development criteria. The literature review showed the importance of supply chains and the use of strategic criteria in managing relationships with suppliers. Based on the model proposed by Oflac (2015), authors studied a local subsidiary of a global company of components for the automotive industry. Through this case study, it was possible to understand how a firm establishes strategies and performs its supply relationship management activities. Results suggest that strong and continuous relationships create advantages for companies, allowing them to remain competitive in their markets. The strategies of selection, evaluation, and development of suppliers enable companies to filter the best partners and develop their capabilities to achieve greater profits.

Chapter 4: Using Big Data Analytics to Forecast Trade Volumes in Global Supply Chain Management

As supply chains become more global, their operations (procurement, production, warehousing, sales, forecasting, etc.) must be managed with consideration of global factors. International trade is one factor affecting global supply chain operations.

Estimating the future trade volumes of certain products for specific markets can help companies adjust their own global supply chain operations and strategies. However, in today's competitive and complex global supply chain environments, making accurate forecasts has become significantly difficult. In this chapter, we present a novel Big Data Analytics methodology to accurately forecast international trade volumes between countries for specific products. Our methodology uses various open data sources and employs Random Forest and Artificial Neural Networks. To demonstrate the effectiveness of our proposed methodology, we present a case study of forecasting the export volume of refrigerators and freezers from Turkey to the United Kingdom. The results show that our proposed methodology provides effective forecasts.

Chapter 5: A Handbook for ITF R&D Project Management

ITF R&D project team and collaborative organizations are this chapter's primary target audience. Other target audiences are project teams like the R&D Centre, research institutions, and universities that are involved in the ITF R&D projects. Industry users are the supporting party or end user of R&D deliverables of ITF R&D projects. This chapter is considered a Standard Operation Procedure (SOP) rather than a policy or strategic document. It is part of the author's engineering doctorate thesis, which was titled "An Analysis of the Determinants of Innovation and Technology Fund (ITF) R&D Projects Commercialization in Hong Kong's Logistics and Supply Chain Industries." The thesis includes five research elements: 1) R&D Technologist Survey, 2) In-Depth Interview of Industry Experts, 3) Survey on Industry User, 4) Pilot Implementation, and 5) Handbook for ITF R&D Project. This chapter is the fifth part of the thesis. The handbook summarizes the first four parts of the research findings and provides the template and operation flow for the project team to consider in its ITF R&D project.

Chapter 6: Forecasting – Investigating the Structural Relationship Among Financial Ratios and Stock Prices

This chapter covers a study on forecasting stock prices, which can be a challenging task due to the amount of information and variability involved. The test approach, research, and results cover fifty companies on the US stock exchange over a six-year period. Company quarterly and annual financial reports, along with daily stock prices, form the data set analyzed. The financial ratios were tested as independent variables against stock prices as the dependent variable. In addition, ratio type comparisons and timing scenarios for leading or lagging indicators were covered. Correlation and multiple-regression tests were used to eliminate some ratios and to find a combination of twelve ratios that successfully account for 35 percent of the variability in stock prices. The results point to leading indicators, statistically significant ratios, and a predictive model for forecasting stock price.

Chapter 7: Leadership 5.0 in Industry 4.0 – Leadership in Perspective of Organizational Agility

In today's competitive environment, agile firms tend to be more successful. If today's technology companies, which are leaders in their sector, fail in that competitive environment, they might lose their market leadership in the future. Some companies, which were at the top of the market in their own sector in the past, are likely to stand back from their competitors for not adapting to market change conditions. Technology designed to speed up processes and the digitalization of communication are taking place in all organizations in all area and in all kind of sectors. Because the business world is being transformed by the postmodern revolution, we are witnessing the Fourth Industrial Revolution. In this dynamic environment, leaders should learn new management behaviors so they can communicate both internally and externally about their enterprises to become innovative organizations. This can be accomplished by being aware of changes in the environment and managing these changes for the company's success.

Chapter 8: The Role of Strategic Sourcing in Global Supply Chain Competitiveness

A global supply chain is a core element for an organization's competitiveness. Its success relies on the synchronization of relations, activities, and agreements in order to be flexible, agile, high quality, and cost-effective for customers. Strategic sourcing emerges as an important factor to support and intelligently integrate suppliers into the supply chain. This chapter discusses how strategic sourcing can contribute to improving a firm's global supply chain competitiveness. To do so, certain elements must be considered while developing the strategic sourcing: the sourcing process cycle, internal and external relations, sourcing risks, global sourcing application, and supplier development.

Chapter 9: Managing Electronic Supply Chains

During the early 2000s, the advent of internet and e-communication enabled organizations to be more responsive and cater to their customers' needs in a better way. Over the last few years, integrated technologies and ERP systems have allowed organizations to gain market share and establish themselves as e-commerce players.

This has been achieved through better synchronization, business realignment, and operational flexibility. Rapid development in information technology fields has transformed old partnerships between suppliers, buyers, and service providers into a more collaborative business process where information and knowledge sharing is a key success parameter. Through enhanced IT capabilities, SMEs can co-operate to form a network and promote their joint capacities to acquire a complex project and integrate resources for better planning and execution. In this chapter, the author highlights the importance of adopting and implementing e-SCM, the current status of adoption through case studies, the benefits of e-SCM as strategy, and the challenges plaguing the adoption of e-SCM.

Chapter 10: Policy Designing via System Dynamics

This chapter successfully explains the system dynamics approach. This approach was developed by Jay Forrester from MIT during the 1950s to analyze the complex behavior in organizations with computer simulation. System dynamics is a form of the systems approach methodology for understanding the dynamic behavior of complex systems. The basis of system dynamics is to understand how system structures cause system behavior and system events. System dynamics deal with how things change over time. Everyone is interested in how the past formed the present moment and how today's actions determine the future.

Chapter 11: Occupational Health and Safety Hazards in Agriculture – A Study on the Risks Involved for Sustainability

Worldwide, analysis of the magnitude of occupational and health safety (OHS) problems is essential in the agricultural sector. However, few studies have analyzed OHS problems in Odisha to assess the prevailing situations. Hence, this study explores the OHS-related issues among the farmers of Odisha, India. This study has two parts: 1) the occupational health and safety issues of Odisha farmers were analyzed based on the literature review and the data collected by personal interaction and questionnaires, and 2) the Step-Wise Weight Assessment Ratio Analysis (SWARA) method.

Chapter 12: Supplier Selection Criterion for SSCM in an Indian Thermal Power Plant – Criteria Responsible for the Selection of a Raw Material Provider in a Thermal Power Plant

All companies are dependent on their raw material provider. The same is true in the case of thermal power plants. The major raw material for a thermal power plant is coal. Many companies provide this coal to the thermal power plant. Some of these companies are international, some are local, and others are localized. Thermal power plants look into all aspects of the coal-providing company before settling down for a deal. Some people are specifically assigned to the task of managing the supply chain. The main motive is to optimize the whole process and achieve higher efficiency. A thermal power plant looks into many things before finalizing a deal, such as the price, quality of goods, etc. Thus it is very important for raw material providers to understand each and every aspect of the thermal power plant's demands. A combination of three methods—Delphi, SWARA, and modified SWARA—have been applied to a list of factors, which have been ranked by weight and other relevant calculations.

Chapter 13: An Analysis of Sustainable Supply Chain Management in Thermal Power Plants – Sustainable Supply Chain Management for Customer Satisfaction in the Thermal Power Sector

For the last decade, researchers and practitioners have been garnering interest in Sustainable Supply Chain Management (SSCM) because of its multi-approach in nature. SSCM has emerged as an essential key method for organizations to develop and enhance their competitive strategy through innovative ways to achieve customers' basic needs. SSCM facilitates competitive advantage, faster flow of information, delivery of materials, less response time, speeding up delivery action, better relation and coordination among partners, and an easier way to share information and increase order fulfilment. Implementing SSCM in organizations like thermal power plants has many benefits such as increasing attention about environmental performance and the need to integrate social and economic performance. In this chapter, the Artificial Neural Network (ANN) method is used to measure customer satisfaction after SSCM is implemented by thermal power industries.

Chapter 14: Investigating the Impact of ERPs on Job Shop Manufacturing Logistics Performance

Job shop manufacturing processes have been reluctant to adopt enterprise resource planning systems (ERPs) for enhancing logistics performance. The cost of adopting and deploying ERPs is a high-entry barrier. Prior research has claimed that performance can be enhanced by improving logistics planning using technology such as ERPs. Most past research has examined the ERPs' effects on logistics performance in production processes other than job shops, which suggests that in small-scale production processes, the cost of ERPs makes it irrelevant. Are manufacturing job shop production processes the exception that proves the rule? Using both a t-test two sample for means and a Kolmogorov-Simonov (KS) test, this study tested whether or not ERPs can improve supply chain logistics performance in job shop manufacturing processes. The results might lead to positive social change in the adoption or non-adoption of ERPs in job shop manufacturing.

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Chapter 1
The Role of Electronic Supply Chains and ERP Systems in the Realm of E-Commerce

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ABSTRACT

Businesses around the world experience many challenges to acquire raw materials, parts, subassemblies, and the other necessary inputs to their production systems. As businesses are all moving into the e-commerce platform to gain market share, they realize that electronic supply chain management (e-SCM) powered by enterprise resource planning systems (ERPs) are the new norms and no business organization can operate without both in the new world of e-commerce. Little attention has been devoted to e-SCM dynamic with ERP and the challenges they pose to organizations. In the e-commerce environment, e-SCM is among the most important factors to organizational success. Effective e-SCM can enhance competitiveness and increase market share leading a higher profitability. Nevertheless, the new e-SCM professionals and other actors must understand the factors that undergird e-SCM performance, their drivers, and the necessity of fully functional ERPs for an effective e-SCM.

INTRODUCTION

Businesses around the world experience many challenges to acquire raw materials, parts, subassemblies, and the other necessary inputs to their production systems. Organizations must work to ensure they excel or simply survive in this extremely competitive environment. As businesses move into the e-commerce platform to

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gain market shares, they realize that electronic supply chain management (e-SCM), powered by enterprise resource planning systems (ERPs), is the new norm and no business organization can operate without both e-SCM and ERPs in the new world of e-commerce. Because business via the internet requires different fulfillment approaches, traditional drivers of regular supply chains are no longer adequate for explaining how e-SCM performance is driven. The task of e-SCM professionals is, therefore, more complicated than ever. This situation often leads to unsatisfied customers, which can force companies to close their doors. Therefore, understanding the dynamics of e-SCM performance drivers and their integration with ERPs, along with their accompanying challenges, becomes a necessity. Little attention has been devoted to e-SCM dynamics with ERPs and the challenges they pose to organizations. This article discusses the new e-SCM challenges facing organizations as they attempt to enter the e-commerce platform. In the e-commerce environment, e-SCM is one of the most important factors to organizational success. Effective e-SCM can enhance competitiveness and increase market share, leading to higher profitability. Nevertheless, the new e-SCM professionals and other key players must understand the factors that undergird e-SCM performance, their drivers, and the necessity of fully functional ERPs for an effective e-SCM.

Information technology (IT) has changed the way businesses conduct their operations (Hanafizadeh, Ghandchi, & Asgarimehr, 2017). Today's IT is at the heart of every business operation. An IT breakdown usually leads to work stoppage. Here are two examples: (1) IT breakdowns often paralyze airport operations, leading to flight cancellations and angry passengers, and (2) a dysfunctional check-in or checkout system creates infinite waiting lines and hinders the company's reputation. Consequently, e-commerce has forced businesses to redesign their operations dramatically (Sambasivan, Mohamed, & Nandan, 2009). E-commerce offers a new venue for revenue generation that sometimes surpasses that of the traditional brick-and-mortar business. E-commerce offers consumers more buying options than does traditional business. Buyers can instantly compare prices, product attributes, and delivery parameters. As a result, customers have become increasingly demanding as they raise their expectations when buying from the internet. On the other hand, e-commerce requires the use of the internet, creating a new SCM challenge. Therefore, e-SCM is becoming an integral part of traditional supply chain management (Gunasekaran, Patel, & Tirtiroglu, 2001; Sambasivan et al., 2009). Consequently, businesses are becoming supply chain-sensitive organizations. With business via the internet requiring different fulfillment approaches, traditional drivers of regular supply chains are no longer adequate for explaining how and to what extent e-SC performance is driven (Sambasivan et al., 2009). The task of supply chain professionals is more complicated than ever because e-SCs rely on ERPs. This situation often leads to unsatisfied customers, which can force companies to close their doors because of lost profit.

Effective SCM is customer-centered and ensures cost-effective resource allocations. However, to be cost-effective, supply chain managers must demonstrate full understanding of factors that drive SCM performance and how to gauge actual performance to take proper actions (Stock & Boyer, 2009). According to Caputo, Cucchiella, Fratocchi, Pelagagge, and Scacchia (2004), SC managers are often driven by their personal experiences and routine methodologies that do not usually lend themselves to the expected results.

Supply chains involve all processes that support demand planning, procurement, production, logistics, and distribution (Petrovic, 2016). E-SCs involve partners that are linked by internet technology in broad networks where customers, retailers, distributors, manufacturers, and suppliers are connected (Fliedner, 2003; Lightfoot, & Harris, 2003; Williams, Esper, & Ozment, 2002). Within and across the networks, key players collect, process, store, and disseminate information on materials, goods, funds, and services. e-SCs are composed of many-to-many connections, while relationships in traditional supply chains are characterized by one-to-one connections. Because of the widespread use of internet technology today, a dramatic revision of current SCM techniques is needed (Caputo et al., 2004). Therefore, understanding e-SCM performance drivers and their integration with ERP becomes a necessity for any SCM professional. Based on the literature survey, little attention has been devoted to SCM performance driver evaluation despite the high volume of ongoing research in the field (Gunasekaran et al., 2001; Sambasivan et al., 2009).

This paper examines the challenges facing e-supply chain management, the performance drivers of e-SCs, the metrics for measuring efficiency, and their integration with ERPs. Considering the fact that e-SCs are becoming an integral part of the extended enterprise (Sambasivan et al., 2009), the first section of this article introduces a model of the traditional supply chain for both manufacturing and service systems. In addition, it assesses the logistical and cross-functional performance drivers of supply chains (Chopra & Meindel, 2010; Olver et al., 2010). The section concludes with a brief comparison between a physical product and information flow.

The second section examines e-SC structures and performance metrics for capturing and gauging system effectiveness and efficiency. It also explains the corresponding measures for the implementation of each metric. It should be noted that e-SC metrics and their corresponding measures are effective ways for managers to ensure that the supply chain is achieving its expected benefits (Riggins & Mitra, 2001).

The role of information technology has shifted from passive enabler to high-performing processes that directly impact the organization's performance. Because e-SC performance requires integration (Smart, 2008), the third section discusses the integration of ERPs into e-SCs to enhance their performance. In this last section, the author discusses the effectiveness and efficiency benefits of ERP for e-SCs (Sambasivan et al., 2009).

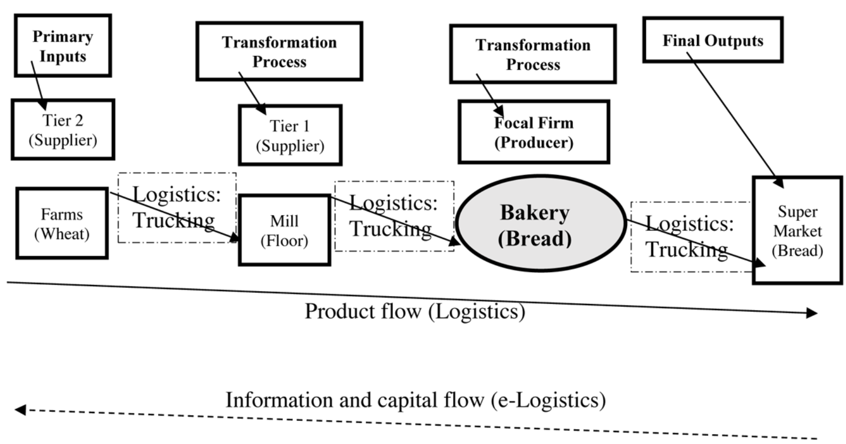
SCM is among the most important factors to organizational success (Gunasekaran et al., 2001). Many benefits of e-SCs are quantifiable while others are not (Singh & Byrne, 2005). Effective SCM can enhance competitiveness and increase profitability. Nevertheless, SCM professionals and other key players must understand the factors that undergird driver performance in order to achieve a competitive advantage.

The fourth section discusses challenges facing e-SCM and some strategies for mitigating the negative effects of these challenges.

BACKGROUND

Supply chains are sequences of organizations involved in the production of a good and/or the provision of a service (Stevenson, 2018). The author argues that organizations generally consist of facilities, functions, or units and that they carry out production or service provision activities. Therefore, their facilities, functions, and activities, which are involved in the production or service provision, are integral parts of supply chains. Facilities may include operating units, such as factories, storage facilities such as warehouses, processing centers, distributions centers, and even offices, since information is manipulated to trigger, move, and track products and services within and throughout the supply chain. Figure 1 depicts an example of a supply chain for bread.

Figure 1. Model of supply chain: Supply chain for bread (Logistics and e-logistics)



As depicted in Figure 1, the chain of supply starts with a farming product: the wheat on a farm. Next, the wheat is transported to the mill that processes wheat and converts it into flour. The primary input to flour is the wheat, and the transformation process converts a non-manufacturing good (wheat) into a manufactured one (flour). The outbound logistics through trucking occur at the farm and the inbound logistics part occurs with the incoming freight at the mill company. The trucking activities from farms to the mill represent the external supply chain. However, internal supply chain activities occur with the mill facilities. These short distance movements within a supply chain partner's facility are often referred to as material handling and transfers. The floor is, therefore, the primary output and the secondary input to the supply chain of bread. The floor is then converted into bread at the bakery facility. The supply chain of bread ends at the supermarket where the customer purchases it. Products flow from suppliers to the end consumer; information and capital flow in the reverse direction.

In general, every product is made through its supply chain within and across multiple sequential organizations. The main conceptual dilemmas have always been: (1) What activities and components of an organization should that organization include in its given supply chain? (2) Where are the boundaries of SCM territory?

The consensus today seems to be that the supply chain begins with the original suppliers of raw materials. This beginning is followed by production in an operating unit and storage in processing centers and warehouses. The supply chain ends with the delivery of the finished item to the user. Therefore, supply chains existed since the creation of the first good. However, developing a consensus definition of a supply chain has not been an easy task for academicians and practitioners.

Stock and Boyer (2009) examined 173 unique definitions of SCM from systematic reviews of the entire decision science field in an effort to frame the adoption of a consensus definition of SCM. The definitions were considered unique because they added at least one new element that differed from existing definitions. This inquiry was performed based on the assumption that in the absence of a uniform, agreed-upon definition, it would be impossible to advance the SCM theory and practice (Stock & Boyer, 2009). The study identified three themes (activities, benefits, and constituents) associated with the definition of SCM. Six sub-themes were also identified. The theme titled "benefits" consisted of three sub-themes: value added, efficiency created, and customer satisfaction. These three sub-themes accounted for 47, 35, and 28 percent, respectively. The theme titled "activities" was credited with physical (materials), services, finances, and information flows counting as its first sub-theme, with networks of internal and external relationships as its second sub-theme. However, a variety of theories continue to exist as to what a supply chain is and how SCM should be defined (Mentzer et al., 2001).

With the advent of the internet and its business applications, the world has witnessed a new type of supply chain, the e-SC. This addition increased confusion regarding the conceptualizations on SCM. Confusions upon definitions of SCM existed in both the academic and practitioner circles (New, 1997; Tan, 2001). This article is based on the existing literature in an attempt to frame a comprehensive understanding of the concept of an e-SC, its performance drivers, accompanying metrics, and integration with ERPs. A framework for structuring e-SC drivers helps to achieve a strategic fit between the supply chain strategy and the organization competitive strategy (Chopra & Meindel, 2010).

BRICK-AND-MORTAR SUPPLY CHAINS

Traditional Supply Chain Models and Drivers

Manufacturing and Service Supply Chain: As previously mentioned, the Stock and Boyer (2009) study that compiled 173 unique definitions of SCM proposed a new consensus and encompassing definition of SCM. SCM is the management of networks of relationships within and throughout organizations consisting of suppliers of raw materials, procurement, production units, logistics, and marketing that facilitate bidirectional flow of goods, services, funds, and information from the original supplier to the end-user with the benefits of adding value and maximizing profit while increasing customer satisfaction (Stock & Boyer, 2009). E-SCs focus on the management of the information flow, managing technology and information processes to optimize the flow of goods, finances, and materials to achieve customer satisfaction and competitive advantage (Srinivasan, 2010).

Model of Manufacturing and Service Supply Chain: Models are selected and used as simplified representations of reality. Models facilitate understanding of phenomenon or concepts. This section introduces models of traditional supply chains for both the manufacturing and service sectors. To illustrate supply chains, Fawcett, Ellram, and Ogden (2007) suggested the following simple models of manufacturing and service supply chains.

1. Simple Model of a Hotel Service Supply Chain
2. Simple model of a manufacturing supply chain

As depicted in Figures 2 and 3, models of supply chains are viewed from the central ring of the chain (also known as the focal firm). The focal firm is the departing point to both the left and the right. Partner firms to the left of the focal firm form the upstream side of the supply chain. Those to the right form the downstream

Figure 2. Simple service supply chain (adapted from Fawcett et al., 2007) (Source: Essila, 2015)

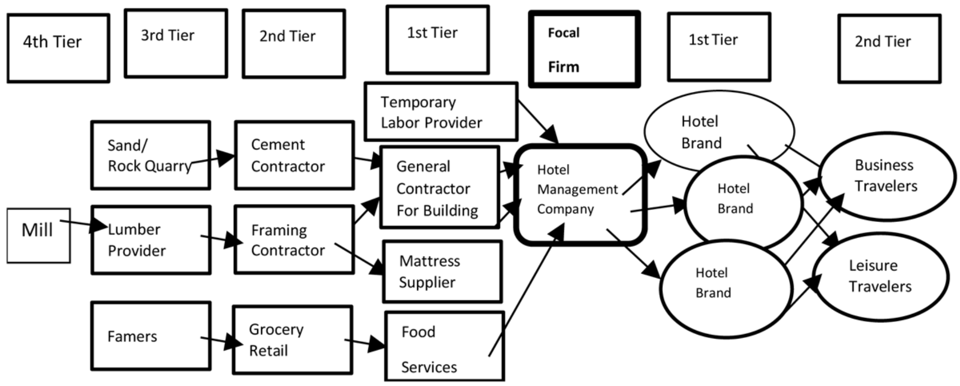
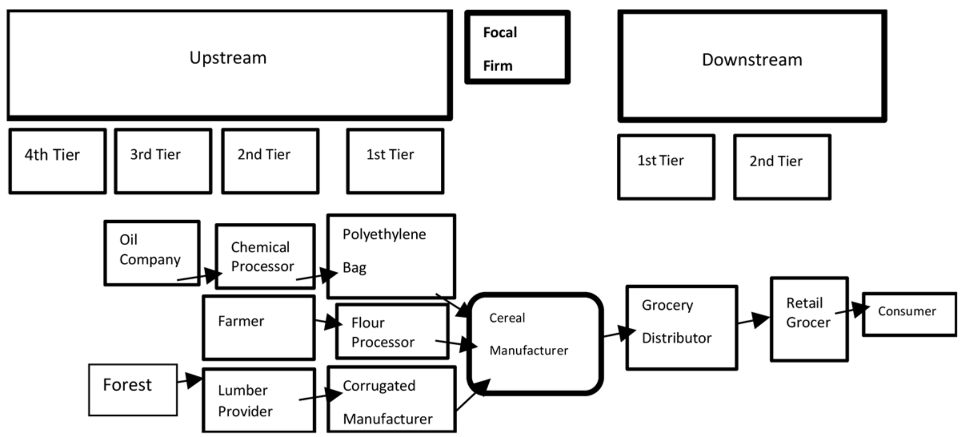


Figure 3. Simple manufacturing supply chain (adapted from Fawcett et al., 2007) (Source: Essila, 2015)



side of the supply chain. Upstream partners are also known as tier “n” suppliers. Most definitions in the literature describe supply chains as the flow of materials, information, services, and funds from the suppliers of suppliers all the way down to the final consumers. The flow is symbolized by arrows as depicted in Figures 1 and 2. Some authors argue that the essence of SCM is to manage the flow of goods and information from the point of departure to the point of consummation, implying a unidirectional flow (Arthur, 1991; Zsidisin, Jun, & Adams, 2000). In fact, information, materials, services, and funds all follow a forward and backward path through the supply chain (Svenson, 2002; Towill, Childerhouse, & Disney, 2001). Svenson explained that the demand information flows upstream from the consumers; materials, funds, and services flow downstream in the supply chain.

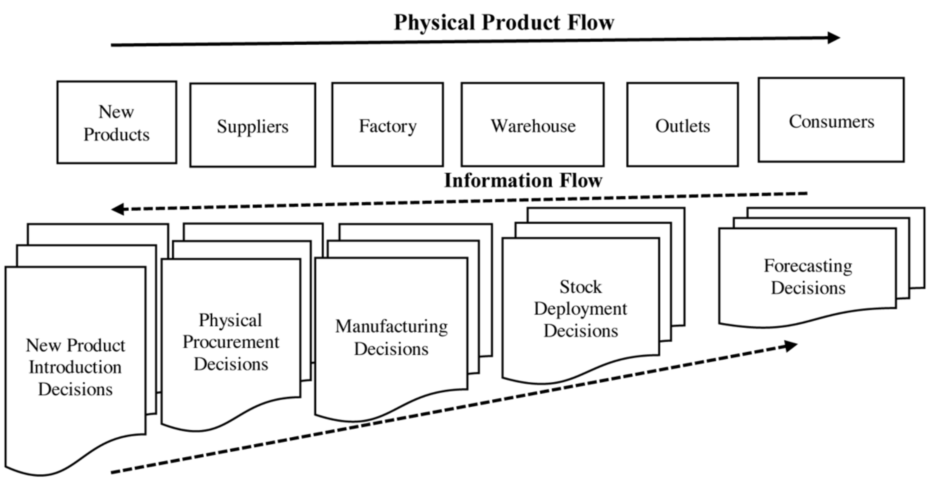
Drivers of Traditional Supply Chains: According to Olver et al. (2010), supply chain performance is driven by both logistic and cross-functional factors. Olver et al. (2010) argue that analyzing supply chain drivers helps to understand how organizations can improve their supply chain productivity to become more responsive and efficient. Logistics drivers are manufacturing and supporting facilities, inventories, and transportation. Supporting facilities are physical locations needed to provide a service (Fitzsimmons & Fitzsimmons, 2011). Hospital buildings, doctors' offices, airplanes, or classrooms are examples of supporting facilities. Cross-functional drivers of supply chains are sourcing, pricing, and information. Information affects and is directly affected by all other drivers. It is, therefore, the biggest driver of a supply chain (Olver et al., 2010). Figure 4 depicts both physical and information flow in the supply chain.

BRICK-AND-MORTAR SUPPLY CHAINS vs. E-SCs

Structures, Drivers, and Measures

e-SCs: e-SCs encompass partners that are connected by internet technology in broad networks where customers, retailers, distributors, manufacturers, and suppliers are all linked (Fliedner, 2003; Lightfoot & Harris, 2003; Williams et al., 2002). Within

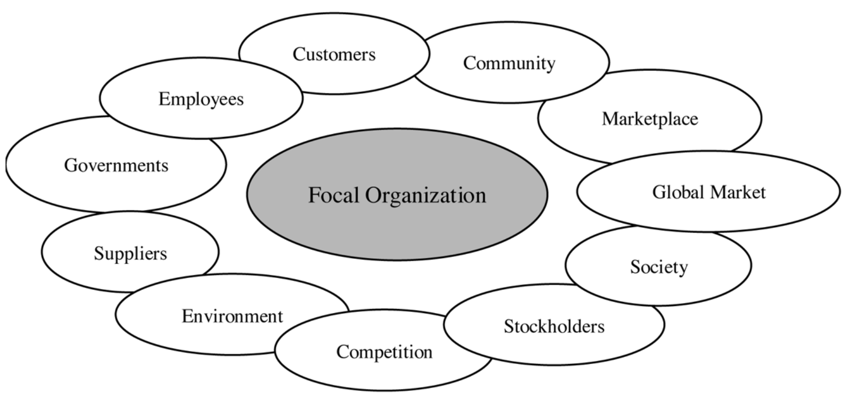
Figure 4. Physical and information flow in the supply chain (adapted from Sherer, 2005) (Source: Sherer, 2005)



and across the networks, the key players collect, process, store, and disseminate information on materials, goods, funds, and services. e-SCs are composed of many-to-many connections while relationships in a traditional supply chain are characterized by one-to-one connections. A dramatic revision of current SCM techniques is needed (Caputo et al., 2004). The primary purpose of e-SCs is to help organizations increase effectiveness, improve efficiency, and achieve strategic benefits, such as revenue increase and competitive advantage, by establishing customer loyalty (Riggins & Mitra, 2001; Van Hooft & Stegwee, 2001). Next, the researcher introduces the structure of a typical e-SC.

e-SC Structures: Wheatley (1999) predicted that in the realm of business, the amount of investment on brick-and-mortar facilities will be replaced by investment in technology. An increase in investment puts more pressure on e-SC managers to achieve high performance in order to yield a higher return on investment. Traditional arm's length, horizontal, and vertical integrated structures are no longer appropriate for e-SCs since they connect organizations. Unlike traditional supply chains, "the electronic supply chain is round in form" (Williams et al., 2001, p. 708). The traditional supply chain goal is to increase responsiveness and efficiency through long-term stability. Traditional supply chains usually build relationships that can achieve a long-term benefit among partners. On the other hand, e-SCs are designed to adapt to the dynamic environment of an e-business. Therefore, they are flexible in nature. Supply chains shape the organizational structure for future performance enhancements. As depicted in Figure 5, firms are connected through information technology. The focal firm is represented by a central ring. Other partners in the e-SC are represented by outer rings.

Figure 5. The e-SC structure (adapted from Williams et al., 2002) (Source: Williams et al., 2002)



Drivers and Metrics of Traditional Supply Chains: Unlike e-SCs, traditional supply chain design initiatives are generally viewed as top to bottom processes similar to the classical waterfall-type model in systems engineering. The examination of the six drivers, along with their corresponding metrics and accompanying measures, reveals the need for more stable relationships with partners. The advent of globalization and the internet has dramatically changed the paradigms. Supply chain leaders need to adjust their strategies and structure the six drivers of traditional supply chains depicted (see Table 1) in order to achieve a high level of responsiveness while minimizing logistics costs to the entire supply chain.

Table 1. Drivers, metrics, and measures of traditional supply chains (developed based on Olver et al., 2010)

Driver Type	Drivers	Metrics	Measures
• Logistical	• Facilities	• Design capacity • Effective capacity • Capacity cushion • Utilization • Efficiency • Product variability	• Production per unit • Production cycle time • Flow time • Flow time efficiency • Production service level • Average batch volume
• Logistical	• Inventory	• Inventory cycle • Safety stock • Product availability • Obsolescence	• Average inventory • Inventory turns • Average replenishment lot size • Rate of obsolete inventory
• Logistical	• Transportation	• Network design • Shipment • Transportation mode selection process	• Inbound cost per period • Outbound cost per period • Inbound average shipment size • Outbound average shipment size • Volume per mode
• Cross-functional	• Information	• Demand forecasting accuracy • Process design type (push vs. pull) • Sharing and coordination • Availability • Accessibility • Enabling technology (ERP, EDI, RFID, and SCM) • Encryption	• Mean absolute deviation (MAD) • Mean squared error (MSE) • Forecasting horizon • Frequency of update • Information velocity • Transactions per users per enabling technology • Reliability of enabling technologies
• Cross-functional	• Sourcing	• In-house/outsource rate • Supplier selection • Purchasing/Procurement • Quality of supply	• Average purchasing price • Purchasing range • On-time deliveries to total deliveries • Receipts defect rate (RDD)
• Cross-functional	• Pricing	• Price menu • Profit	• Range of sale price • Average sale price • Incremental fixed/variable cost per unit

Drivers and Metrics of e-SC: As mentioned, drivers of traditional supply chains are facilities, transportation, inventory, information, sourcing, and pricing. They are classified as either logistical or cross-functional performance drivers (Olver et al., 2010). Unlike traditional supply chains, factors that affect e-SC performance are the *adapted organizational structure*, which effectively manages relationships among network partners, the *managerial criteria*, and the e-SC *critical activities* (Caputo et al., 2004). Critical activities can, therefore, be viewed as logistical drivers. The organizational structure and managerial criteria can be viewed as cross-functional drivers of the e-SC factor equation.

Due to their unique characteristics, e-SCs need new metrics to adapt to challenges using innovative solutions that take into account the new dynamic environment (Barnes & Hinton, 2007). Little attention has been given to supply chain metrics and their accompanying measures (Sambasivan et al., 2009). Effective SCM requires an optimal balance between responsiveness and efficiency. Because each driver interacts with the others, supply chain managers must effectively combine the logistical and cross-functional drivers to avoid conflicting goals (Olver et al., 2010). From a practical perspective, the working technique is to increase positive impacts while minimizing the negative effects on the entire logistics system. A strategic alignment between the supply chain strategy and the organization competitive strategy is also important. Since competitive strategies support corporate strategies, the necessary strategic alignment becomes a central nerve for e-SC performance.

In SCM, metrics track and gauge performance of each driver, as well as the impact resulting from its interaction with the others. Sambasivan et al. (2009) suggested six practical metrics for e-SCs: Web-enabled service, data reliability, time and cost, e-response, invoice presentation and payment, and e-document management. e-SC metrics capture performance both at the aggregated and organizational level. The aggregated level measures the performance of the entire supply chain, encompassing all partners to the supply chain. The organizational level focuses on individual organizational performance, including the process and the performer levels. The accompanying measures for each performance metric are summarized in Table 2. It provides a summary of the three e-SC drivers, in addition to their metrics and measures.

Information is the key driver of both traditional and e-SCs because it serves as the connector to all drivers (Olver et al., 2010). Information affects and is affected by all supply chain drivers. It triggers logistical and cross-functional processes associated with supply chain performance factors. For example, information on customer demand is the basis for the aggregate plan that establishes operation capacity. The operation capacity and capability dictate the rules for establishing schedules for specific products or groups of similar items. At this planning stage, basic strategies are formulated to meet demand using a chase demand or level capacity strategy.

At every stage in the supply chain process, bi-direction flows of information play a critical role. As a leading performance driver, information sets the stage for potential productivity gains for both logistical and cross-functional processes within, across, and throughout the entire supply chain. Information is a cross-functional driver of a supply chain (Oliver et al., 2010). As depicted in Table 2, information is a major supply chain driver of traditional and e-SCs. All supply chains often rely on enabling technology such as ERP, electronic data interchange (EDI), radio frequency identification (RFID), and SCM software. For e-SCs, enabling technology is a necessity. Such technology enables organizations to collect, store, process, and disseminate information within and across the entire supply chain. Next, the article will explain the necessary integration between e-SCs and ERP.

Table 2. e-SC metrics and their accompanying measures (developed based on Caputo et al., 2004; Sambasivan et al., 2009)

Driver Type	Drivers	Metrics	Measures
• Logistical	• Adapted organizational culture	• Web-enabled service	• Data access time • System response time • Data transmission speed between business-to-business applications • Number of system verification steps • Traffic volume per page and/or site
• Cross-functional	• Managerial criteria	• Transaction reliability	• Number of transaction errors • Number of backlog transactions • Number of partners accessing the system • Cost per transaction • ERP interface cycle time
• Cross-functional	• Managerial criteria	• Cost	• Administrative cost
• Cross-functional	• Critical activities	• Time	• Administrative time • Number of stages in the purchasing cycle • Purchasing lead time • Procurement cycle time • Procurement response time
• Logistical	• Adapted organizational culture	• E-Response	• Reliability of mail service • Completed number of transactions per period (day, week, or month) • Pending number of transactions per period (day, week, or month)
• Cross-functional	• Adapted organizational culture	• E-Invoice process	• Number of steps involved • Dispute resolution completion time
• Logistical	• Adapted organizational culture	• E-Payment	• Payment time • Reconciliation time
• Cross-functional	• Managerial criteria	• E-Document	• Data accuracy • Data reliability

E-SC INTEGRATION WITH ERP

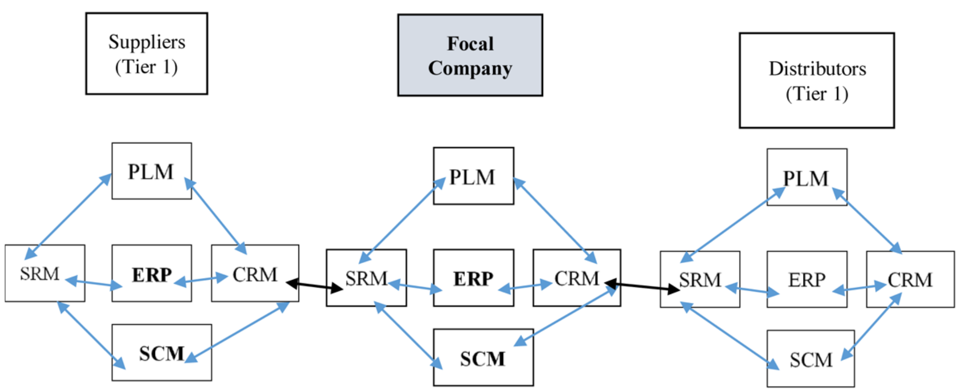
ERP Integration

ERPs, the third generation of enterprise systems (ESs), began with material requirements planning (MRP) in 1964. This was followed by manufacturing resource planning (MRP II) in 1983. ERPs are currently the most complex version of ESs to integrate both the functional and cross-functional process in the organization. ERPs have MRP as their core system. ERPs support all business function operations and transactions, linking them in a uniform platform to make information available in real-time across the organization's entire supply chain. ERPs track the information within and across organizations. The internet provides a broad visibility of the information. Supply chain managers utilize information provided by ERPs as the basis for making informed decisions.

A close look at an ES application suite reveals the necessity to integrate ERPs with SCM software. As depicted in Figure 5, the five basic components of a simple ES are the product life cycle management (PLM), the supplier relationship management (SRM), the ERP, the SCM, and the customer relationship management (CRM). ERPs are the epicenter of ESs because they integrate and connect the other ES components.

ERP systems are configurable ESs designed to integrate processes and information within and across organizations (Kumar & Van Hillegersberg, 2000). ERPs allow organizations to automate repetitive tasks, underlining transactions and processes. If properly used, SCM can be improved by integrating ERPs. Organizations that are best placed to succeed are those that have implemented an adequate business infrastructure utilizing ERP capabilities (Srinivasan, 2010). ERPs help to increase velocity in the supply chain fulfillment process.

Figure 6. Enterprise application suite in the supply chain (adapted from Magal & Word, 2011) (Source: Magal & Word, 2011)



E-SUPPLY CHAIN'S DYNAMICS WITH ERP AND CHALLENGES

The presence of various forces, such as electronic supply chain management (e-SCM) and enterprise resource planning systems (ERPs), within the organization creates a dynamic that often poses many threats and challenges to business operations. The interaction between e-SCM and ERPs provides an opportunity to gauge e-SCM performance under ERPs and vice-versa.

FUTURE RESEARCH DIRECTIONS

This article identified variables relevant to the measurement of an effective e-SC. A similar study with more focus on the relationship among e-SC performance drivers that would allow a moderate (or even excessive) interference with a purpose of establishing a more elaborate causal relationship would provide more insight into the underlying construct. A longitudinal field experiment on the subject would also derive more detailed information about performance drivers of e-SCs.

Research could also be directed toward testing the hypothesis about the quality of enabled-technology used in an e-SC, as well as its effect on both efficiency and responsiveness. Suggested questions and ideas include:

1. Does full use of technology in the e-SC lead to greater effectiveness and a higher return to stakeholders?
2. What factors influence how supply chain professionals feel about the full use of technological supply chain capability?
3. If an entirely automated e-SC system were possible, would it be more effective?
4. Research could look more closely at traditional supply chains and technologically-assisted e-SCs to elaborate a classification of technologically-assisted e-SC systems with a measure of the extent or magnitude of technology involved.

CONCLUSION

As businesses are all moving into the e-commerce platform to gain market shares, they realize that electronic supply chain management (e-SCM), powered by enterprise resource planning systems (ERPs), is the new norm and no business organization can operate without both e-SCM and ERPs in the new world of e-commerce. Because business via the internet requires different fulfillment approaches, traditional drivers of regular supply chains are no longer adequate for explaining how e-SCM performance is driven. The task of e-SCM professionals is, therefore, more complicated than ever. This situation often leads to unsatisfied customers, which can force companies to close their doors. Therefore, understanding the dynamics of e-SCM performance drivers and their integration with ERP along with their accompanying challenges becomes a necessity. With the advent of globalization and the emergence of e-business, e-SCs are imperative. Organizations now compete using marketing, operations, and supply chain functions. Companies are no longer competing as stand-alone entities in today's business dynamic environment (Lambert & Cooper, 2000).

This article reviewed the six performance drivers of traditional supply chains based on the Olver et al. (2010) framework: facilities, inventory, transportation, information, sourcing, and pricing. The first three are referred to as logistics drivers because they are directly responsible for moving materials, funds, information, and service throughout supply chain pipelines. Information, sourcing, and pricing are known as cross-functional drivers of supply chains because they involve many business functions and processes. Traditional supply chain drivers aim to build long-term relationships among partners. They involve one-to-one relationship types. Early supply chains were arm's length and horizontally and vertically integrated in nature.

The emergence of the internet and e-business calls for new types of supply chains—e-SCs. Unlike traditional supply chains, e-SCs are round in nature (Williams et al., 2001), and involve a many-to-many relationship among their partners. An e-SC initiative is designed to adapt to a dynamic environment. Therefore, they strive for flexibility and adaptability. e-SCs also require more enabled-technology than their traditional supply chain counterparts. As a result, performance drivers of traditional supply chains are no longer appropriate when explaining e-SC performance. Also, business via the internet requires different fulfillment approaches, making traditional drivers of regular supply chains no longer adequate for explaining how and to what extent e-SC performance is driven (Sambasivan et al., 2009).

A dramatic revision of current SCM techniques is needed (Caputo et al., 2004). Based on the framework suggested by Caputo et al. (2004), this article introduced three e-SC performance drivers: the adapted organizational structure for effectively managing many-to-many relationship types among network partners, the managerial criteria, and the e-SC critical activities. Enabled-technology employed by e-SCs are specific ESs such as ERP. ERPs are the third generation of ESs that began with MRP and MRP II. Effective integration of ERPs into e-SCs can significantly improve responsiveness and yield a high return on investment. Understanding drivers of e-SCs helps managers to better structure drivers to achieve their desired level of service at a minimal cost while increasing customer satisfaction and competitive advantage. In the e-commerce environment, e-SCM is one of the most important factors to organizational success. Effective e-SCM can enhance competitiveness and increase market share, leading to a higher profitability. Nevertheless, the new e-SCM professionals and other key players involved must understand the factors that undergird e-SCM performance, their drivers, and the necessity of fully functional ERPs for an effective e-SCM.

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KEY TERMS AND DEFINITIONS

Logistics: That part of SCM responsible for moving materials, funds, information, and services from the point of origin to the point of consumption.

Logistics Capabilities: Ability to employ logistics capacities to achieve the desired level of responsiveness at the lowest cost possible.

Logistics Capacities: Includes physical assets, such as buildings, plants, factories, manufacturing centers, processing centers, distribution centers, warehouses, utilities, human resources, computers, cars, trucks, trains, aircrafts, ships, materials and goods, and supporting information.

Logistics Protocol: Sequence in which logistics activities are to be performed according to specific mathematical models.

Strategy: Set of actions designed and employed to achieve goals.

Supply Chain Facilities: Operating units (such as factories), storage facilities (such as warehouses), processing centers, distribution centers, and even offices since information is manipulated to trigger, move, and track products and services within and throughout the supply chain.

Supporting Facility: Supply chain facility necessary before a service can be provided (i.e., hospitals building, classrooms, airplanes, etc.).

Chapter 2
Framework for Measuring the Performance of Production Operations in the Dairy Industry

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ABSTRACT

For the business operations in the dairy industry, the quick, safe, and hygienic production processes are of crucial importance. The chapter is aimed to develop a framework for evaluating the performance of production operations in dairy industry. An optimum production model is developed through factor analysis and structural equation modelling (SEM) methods applied to the responses collected from different dairy industries. The hypotheses testing suggests that all five factors positively affect the production operations of dairy supply chain. The outcome of the study reveals that the dairy industry needs significant improvement in their production operations to attain competitiveness. Further, this study is helpful for the dairy industry in handling the demand fluctuation, execution of effective production and information systems, improved product quality, process flexibility, etc.

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INTRODUCTION

India ranks first in the milk production and perceived approx. 4% growth annually in the last three decades which far surpasses the average global progress of approx. 1%. The primary goal of Indian dairy industry is to upgrade the milk production as well as milk processing through technological interventions. Currently, there exists 170 milk producers' cooperative (coop.) unions being united into 22 milk marketing federations at state level in India. Milk unions save the milk producers from unfair trade practices of *middlemen, dudhiyas* (milkmen in unorganized sector) and *milk contractors* thereby improving their economic condition tremendously (Mor *et al.,* 2018b; 2018c). The organized sector handles about 30% of the milk whereas the rest of the milk is being controlled by unorganized sector in the industry. The structure of the Indian dairy sector comprises of private units, coop. societies, milk unions, and coop. dairies. The primary objective of building the milk unions was to provide a ready market to the milk producers for the sale of milk in the villages through the coop. and to provide wholesome hygienic good quality processed milk to the urban consumers at a competitive price. Dairy supply chains start with procuring the milk from the farmers, transportation to the plant, milk processing, packaging and distribution to the retailers and finally to the consumer. Agri-food supply chains can be managed effectively through technological innovations and eradication of non-value adding activities along with green manufacturing practices. The milk processing sector entails improvement in the competitiveness status to fulfil the food safety & quality guidelines globally (Bhardwaj *et al.,* 2016; Mor *et al.*, 2018a; 2018d; 2015). structural equation modelling (SEM) is a useful multivariate statistical method which has vast applications since its development in the 1980s. It is used to calculate the consistency and validity of the model of agile manufacturing predominant in the automotive industries (Robertsa *et al.,* 2010). SEM is favored by the academicians as it evaluates the multiple and integrated problems as a sole analysis and it allows the analysis of associations between multiple predictor and response variables (Bagozzi and Yi 1988). A linear structural SEM approach can be used to validate enablers of sustainable practices developed through interpretive structural modelling (Thirupathi and Vinodh, 2016). SEM methodology based on the Malcolm Baldrige measures can be used to estimate the performance of environmental aspects of SMEs (Hussey and Eagan, 2007). The SEM methodology includes two categories of variables, viz., endogenous & exogenous variables (Vinodh and Joy, 2012a). Latent variables cannot be perceived directly as a result of their abstract nature, whereas, the observed variables comprise unbiased facts and are easy to evaluate (Xiong, Skitmore, and Xia (2015). SEM can be used to study the structural associations and an interaction amid measured dimensions of model and its latent constructs (Tenenhaus, 2005). Vinodh *et al.,* (2012b) worked on turbulent market changes through an agile model using the SEM. Sitek and Wikarek (2015) established a hybrid framework by means of mathematical and constraint programming to develop the decisions of sustainable supply chain.

LITERATURE REVIEW

Mangla *et al.* (2016) highlighted the critical factors that are essential for an industry to upgrade the overall business efficacy. Patushi and Kume (2014) endorsed the cluster growth approach to improve the business effectiveness in Tirana. Ayodele *et al.* (2014) recognized the research issues in the knowledge optimization approaches & their usefulness in food sector. Okano *et al.* (2014) offered an organization of milk chain to prove that it is likely to unify the estates of milk processing sector through modelling the best practices for productivity development. Lemma *et al.* (2015) offered the optimization methods applied in fresh food sector and waste control via benchmarking the best modelling practices. Kumar (2014) intended to assess the practicality of a theoretical model in dairy sector and projected an integrated model for assessing the performance of supply chain. Prakash and Pant (2013) conducted a study of dairy industry and established how the balanced scorecard method can be applied to quantify the overall performance. Prasad and Satsangi (2013) studied the association among designs of an enterprise with its performance indicators at Amul dairying system. Singh *et al.* (2011) found that a loss of 72% of perishable food products due to no use of information technology by the unorganized venders of fresh food in Pune. Kumar *et al.* (2011) determined that the contemporary milk system, and found that the traceability supports in solidification of supply chain. Punjabi (2009) considered the factors responsible for effectiveness of dairy sectior by means of a performance analysis. Quality management seems to be a significant factor in the dairy subsequently the inventory management, supplier management and technological innovations (Mor *et al.,* 2017; 2018e). An extensive literature review for individual performance measure of production operations management has been presented in Table 1.

Aramyan *et al.* (2007a) proposed a framework to determine the performance of food supply chain and decided the competence, flexibility, and quality as key performance points. Ondersteijn *et al.* (2006) offered a framework for developing the innovative food supply chain systems and the consequences, opportunities as well as bottlenecks in performance measurement. Beamon (1999) offered an outline of the performance points in supply chain models and their selection for manufacturing sector. Bititci *et al.* (1997) recognized two critical fundamentals of the performance measurement approach i.e. integrity and deployment. Gunasekaran *et al.* (2001) studied the performance measurement of supply chain at strategic and

Table 1. Literature on production operations management

Production Performance Measures	Supporting References
Quality Management	Koulikoff-Souviron and Harrison (2010); Flynn *et al.* (2010); Ramana *et al.* (2013); Talib *et al.* (2013); Ozer (2003); Pant *et al.* (2003); Lancioni *et al.* (2000); Ngai *et al.* (2004); Harwood and Chapman (2009); Mor *et al.* (2018d; 2018e); Garg *et al.* (2016); Kharub *et al.* (2018)
Technological Innovations	Ceccagnoli *et al.* (2009); Saunila (2014), Mor *et al.* (2015, 2016, 2017, 2018a, 2018b); Hauser *et al.* (2007); Singh *et al.* (2010); Sabatier *et al.* (2010); Saxena and Sahay (2000); Singh *et al.* (2006, 2008); Rahul and Kaler (2013); Pedroso and Nakano (2009); Bhardwaj *et al.* (2016)
Strategic and Resource Management	Porter's (1985); Barney (1991); Grant (1996); Boselie *et al.* (2005); Collins and Smith (2006); Guest (2011); Combs *et al.* (2006); Boswell *et al.* (2006); Boswell and Boudreau (2001); Colvin and Boswell (2007); Lee (2000); Cao *et al.* (2008); Singh *et al.* (2010), Singh *et al.* (2012); Kumar *et al.* (2014); Huselid (1995)
Supply Chain Supporting Factors	Lee (2000); Cao *et al.* (2008); Singh *et al.* (2010); Singh *et al.* (2012); Kumar *et al.* (2014); Singh *et al.* (2008b); Thakkar *et al.* (2008); Kumar *et al.* (2012); Kumar *et al.* (2014); Vachon *et al.* (2009); Tan *et al.* (2002, 2003); Bhardwaj *et al.* (2016), Mor *et al.,* 2018c, 2018d)
Operations Management	Halley and Beaulieu (2010); Lambert and Cooper (2000); Das (2001); Shin *et al.* (2000); Gunasekaran *et al.* (2001); Singh *et al.* (2010); Olhager and West (2002); Lambert *et al.* (1998); Singh (2013); Lummus and Vokurka (1999); Jharkharia and Shankar (2006); Hsu *et al.* (2009); Zhao and Lee (2009); Mor *et al.* (2016; 2017); Arshinder *et al.* (2007); Li *et al.* (2005, 2006)

operational level, and also offered the key performance metrics. Lai *et al.* (2002) explored the factors of performance measurement in transport logistics and found valid results. Aramyan *et al.* (2007b) offered a conceptual framework for defining the supply chain operations in food sector. Persson and Olhager (2002) evaluated the supply chain designs for performance parameters and the associations among different parameters.

Research Gaps

The literature review illustrates that there exists no study that comprehensively explores the production operations of the dairy industry in a real-time industrial scenario. The proposed framework is an attempt to fill the research gap by exploring production operations and to include the different constraints that significantly helps in improving the supply chain performance of the dairy industry. Thus, this is a unique study in itself which explores the production operations of the dairy industry.

PROBLEM FORMULATION

The researches in milk production & processing area rely upon dairy science & technology and it does not consider comprehensively the production operations in a real-time industrial scenario, especially in Indian context. Hence, the current chapter analyzes the production operations of dairy supply chain. An optimum competitive production model has been developed by applying the exploratory structural equation modelling (SEM) techniques. The SEM methodology has been applied to the responses obtained through a questionnaire survey. The study aims:

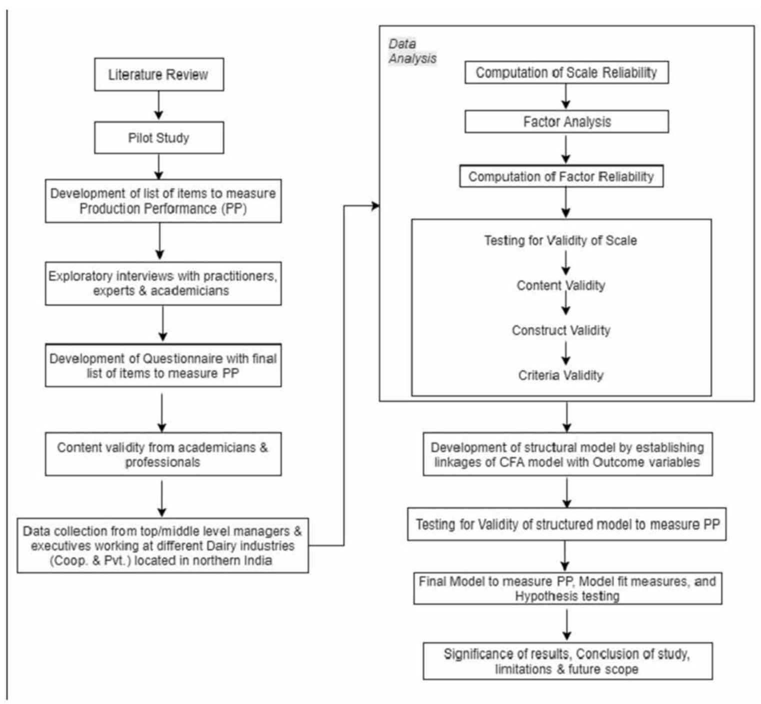
- To bring out the various production issues in the dairy supply chain.
- To develop an optimum model for measuring the production performance in dairy industry.

METHODS

An optimum production model has been developed through factor analysis and structural equation modelling (SEM) methods in the current chapter. SEM measures the complex problems and develop linking between the predictor and variables. The indicators in statistical modelling development are certainly the beginning of the SEM procedures (Goldstein, 1986; Kharub *et al.,* 2018). Thirupathi and Vinodh (2016) studied the application of interpretive structural modelling along with SEM to form structural interaction among enablers of sustainable manufacturing. Hussey and Eagan (2007) applied SEM methodology and determined that the global ecological model for SMEs is effective but it cannot be imperative statistically. Vinodh and Joy (2012c) studied the critical factors for sustainable manufacturing in unlike manufacturing units in India using SEM and built a conceptual model consisting of enablers as criteria and attributes. Hou *et al.* (2014) explored the association among sustainable operations and the factors responsible for behavior fluctuations in the remediation area. Vinodh and Joy (2012a) applied the SEM tool on the empirically collected data to assess the lean manufacturing operations in various organizations in Tamil Nadu. Eid (2009) explored the factors responsible for world-class manufacturing and its assessment through the SEM approach. Kadipas and Pexioto (1999) worked on the comprehensive business practices using SEM and found that the applications of SEM for exploring the relationships among variables and their quantification. Maani *et al.* (1994) studied the quality development practices in manufacturing focusing on direct & indirect relations among quality, productivity, and manufacturing performance. Prajogo (2005) observed the transformation amid manufacturing and service sector for the execution of total quality management and their relationship using SEM. Lau *et al.* (2010) conducted a study of supply-chain integration & product modularity, and indicated SEM as an effective method in supply-chain design and product development. Curkovic (2003) studied the environmentally-responsible-manufacturing using SEM. Jharkharia and Shankar (2006) concluded that the supply chain features like direction in operations management, trading power and the development of chain positively influence the adoption of SCM operations.

A pilot study has been directed to diagnose the key issues, enablers and barriers of production operations in dairy supply chain. The pilot study comprise of experts from academics as well as the dairy industry. Finally, suggestions of experts were incorporated to bring out the production issues of dairy industry. Based on the pilot study & literature review, a questionnaire was developed including the issues of production operations. The questionnaire was improved after focus group conversation with dairy professionals and academicians Morgan (1993; 1996). The first section of questionnaire comprise 22 statements related to the production operations and 1 item measuring the inclusive performance of production operations, whereas, the second section focused on the demographic info of the industry. Prior to launching, the questionnaire was tested through pilot study as suggested by Robson (2002). Figure 1 represents the research methodology flowchart.

Figure 1. Research methodology flowchart



To assess the performance of production operations in dairy industry, both cooperatives & private dairy industries were selected. The questionnaire has been circulated to approx. 500 persons with a request to provide their views about the statements related to production operations in the dairy industry. The same questionnaire has been developed online (Google Forms) also. Responses have been recorded through both personal visits to the dairy industries as well as via online after verifying their identity (Nargundkar, 2004). The respondents were requested to fill their observations for the production issues on 5-point Likert scale (1= strongly disagree, 5= strongly agree). The confidentiality of participants was maintained which aided to attain unbiased responses (Robson, 2002; Saunders *et al*., 2009). A total of 325 responses were received from all levels, i.e. managing directors, unit heads, senior managers, general managers, executives, and head of different divisions, etc. with a very good response rate of 65%. Out of the responses received, 265 valid responses have been considered for further analysis. Since the questions to measure the production performance (PP) have been synthesized from the literature and pilot studies only, it is essential to evaluate the scale through reliability and exploratory & confirmatory factor analysis process.

DATA ANALYSIS, RESULTS & DISCUSSION

Reliability Analysis

The reliability of collected data was judged through Cronbach alpha which describes equivalence and homogeneity of the items used in constructs. The output of Cronbach's alpha value (0.926) indicate high reliability of the collected data (Cronin and Taylor, 1992; Lee *et al*., 2000; Cronbach, 1951).

Factor Analysis

All the 22 issues related with production operations, called as statements here, have been considered for exploratory factor analysis (EFA). Firstly, Bartlett test of Sphericity has been applied to check the relevance of factor analysis which is calculated through correlation matrix of data (Hair *et al*., 2005). At the same time, sampling adequacy (N= 265) was checked by Kaiser-Meyer-Olkin (KMO) numbers which lies between 0 to 1. KMO of >0.6 is assumed to be substantial, and it is 0.903 in current study. The other values provided by SPSS v22 software in current study are as: Chi-square 4103.861, df: 231, Sig.: 0.000, thus demonstrating the aptness of factor analysis (Hair *et al*., 2005).

EFA is directed through principal component analysis (PCA) approach with Kaiser Normalization (5 Factors) and Varimax rotation process in SPSS. The aim of EFA is to recapitulate the data enquired in 22 points into a reduced set of new points to develop constructs for measuring production performance. This led to the extraction of 5 factors explaining the 72.16 percent of the total variance. The individual factors explained 15.97, 14.92, 14.28, 13.83, and 13.13 percent of variance correspondingly and the factor loadings were found to be consistent with the suggested factor structure (Table 1). Now, the factors were termed as: Supply chain supporting factors; Strategic & resource management; Quality management; Technological innovations; and Operations management. All the items depicted the commonalities of ≥0.50 indicating as significant (Hair *et al.*, 2005), and substantial factor loadings i.e. ≥0.55 value (Pitt *et al.*, 1995), Table 1. The internal reliability of statements was studied using the Cronbach alpha coefficient as recommended by Bagozzi and Yi (1988). The reliability score of factors remains between 87.2% to 88.2% (Table 2) in current study and hence, adequate (Nunnally, 1978).

Confirmatory Factor Analysis (CFA)

CFA was conducted to authenticate the scale for evaluating production performance. CFA approves the factor structure by checking the CFA model fit which was run through SPSS AMOS v21 software. The model fit has been studied for individual factor (Table 3) as recommended by Sureshchandar *et al*., 2002; Beinstock *et al*., 1997).

All the GFI (Goodness of fit indices) values came out to be >0.9, thus validating the individual factor of CFA model (Hair *et al*., 2005). CFA model with 5 factors and 22 statements is described in Figure 2.

Model Fit

The values of GIF and Normed Chi-square for current model came out to be 2.510, and thus depicting a good model fit (Bollen, 1993; Tanaka, 1987). The values of GFI, Normed fit indices (NFI) and Comparative fit indices (CFI) came out to be 0.861, 0.883, and 0.925 respectively, and RMSEA >0.07. Hence, it is conferred that the developed CFA model implies an adequate fit.

Interpretation of Factor Structure

The five factors stipulate the key production issues of dairy supply chain. The total variance explained was 72.16 percent by five factors. The results suggested that 5

Table 2. Exploratory factor analysis

Factor No.	Statements (Name & Label)	Commo nality	Factors					Mean	Standard Deviation	Overall Score of Factor	
			F1	F2	F3	F4	F5	Measurement (5-point Likert Scale)		Mean	Standard Deviation
F1	**Supply chain supporting factors (F1)**										
	PRD37 Support for the human resource development (employee welfare, incentive schemes trainings etc.)	0.654	0.778					4.52	0.784	4.488	0.826
	PRD40 Support for the transportation, infrastructure and information system	0.664	0.589					4.55	0.722		
	PRD38 Support from Govt., lower taxes, lower social costs etc.	0.832	0.742					4.41	0.929		
	PRD36 Support for the innovations/R&D budget (technology, design etc.)	0.739	0.801					4.47	0.87		
F2	**Strategic & resource management (F2)**										
	PRD24 Your supply chain management policy is clearly incorporated into the overall business strategy	0.868		0.757				4.32	0.853	4.258	0.882
	PRD25 You are satisfied with the employee welfare measure prevailing in your industry	0.581		0.770				4.32	0.878		
	PRD21 You are satisfied with the level of commitment of human resources to be more competitive	0.708		0.669				4.11	0.941		
	PRD27 You continuously work towards cost cutting by reducing inventories, wastages etc.	0.696		0.791				4.28	0.857		
F3	**Quality management (F3)**										
	PRD33 You face quality issues due to poor maintenance/cleaning of machinery & milk pipelines	0.783			0.670			4.47	0.728	4.424	0.733
	PRD31 Your production system ensures prompt identification of poor quality operations	0.792			0.728			4.46	0.656		
	PRD32 Your information system leads to better supply chain coordination and the product quality	0.78			0.782			4.4	0.748		
	PRD35 You face quality issues due to manual operations & unhygienic practices during milk processing	0.749			0.505			4.48	0.729		
	PRD34 You have benchmarked the best available brands & work continuously for product quality improvement	0.8			0.737			4.31	0.805		

continued on following page

Table 2. Continued

Factor No.	Statements (Name & Label)	Commo nality	Factors					Mean	Standard Deviation	Overall Score of Factor	
			F1	F2	F3	F4	F5	Measurement (5-point Likert Scale)		Mean	Standard Deviation
F4	**Technological innovations (F4)**										
	PRD15 You are satisfied with the sufficient budget allocation with R&D in your industry	0.791				0.894		3.59	1.273	3.670	1.258
	PRD16 You are satisfied with machinery/technology as per latest industry standard in your industry	0.728				0.805		3.67	1.133		
	PRD14 Your Whey treatment facility is highly effective & it adds value to the Cheese-waste	0.602				0.704		3.89	1.286		
	PRD8 You have implemented the latest IT infrastructure like ERP, SAP, Jaguar, PeopleSoft etc.	0.854				0.821		3.45	1.367		
	PRD4 You are satisfied with the level of automation in production processes in your industry	0.637				0.779		3.75	1.233		
F5	**Operations management (F5)**										
	PRD13 Your cold chain infrastructure is highly effective	0.554					0.742	4.42	0.813	4.453	0.759
	PRD3 Your master production schedule is highly effective	0.718					0.823	4.46	0.712		
	PRD2 You are satisfied with level of coordination b/w various deptt. such as Prod, QC, Mktg. etc.	0.685					0.664	4.53	0.754		
	PRD1 Your production system responds rapidly to the fluctuations in demand	0.711					0.758	4.4	0.758		
Reliability (Cronbach Alpha# value) of recognized factors			0.879	0.876	0.882	0.879	0.872				

Extraction Process: Principal Component Analysis.

Rotation Process: Varimax with Kaiser Normalization.

[a]Rotation converged in 5 iterations.

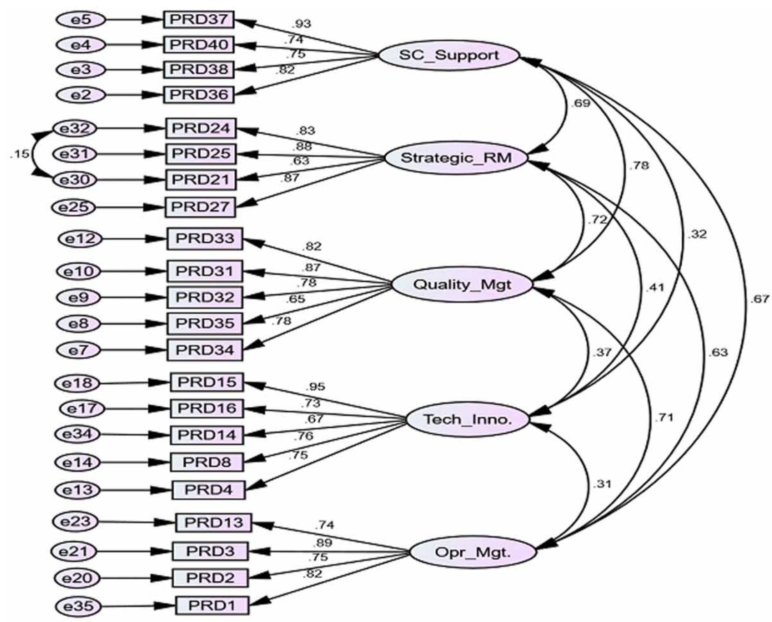
•F1 - F5 represents the individual factors and all the factor loading are ≥ 0.55. The Cutoff point for loadings is 99% significant and is calculated by $2.58/\sqrt{n}$ (Pitt*et al.*, 1995) where n (=22) is the number of items in the scale.

#α values ≥ 0.70 are adequate (Nunnally, 1978).

Table 3. Key Fit indices for CFA model of production operations

Factors	(χ2)/df = Cmin/df	RMR	GFI	NFI	CFI	RMSEA
F1: Supply chain supporting factors	2.261	.014	.988	.989	.992	.070
F2: Strategic & resource management	1.606	.007	.997	.994	.999	.048
F3: Quality management	0.468	.005	.996	.997	1.00	.000
F4: Technological innovations	2.45	.070	.975	.967	.974	.068
F5: Operations management	2.807	.010	.989	.990	.993	.070

Figure 2. CFA Model development for production operations



factors (dimensions) can explain significantly the production performance of dairy industry. The mean scores and SDs of 22 statements with their underlying factors were determined by IBM SPSS v22 software (Table 2).

The 1st factor labelled as 'Supply chain supporting factors' accounts for 13.14% of the total variance. 4 statements describing the factor, having the factor loadings of 0.589 to 0.801 were encompassed (Table 2). The factor draws relevance from the statistical point of view as well as the literature. Based on the first factor drawn, following null hypothesis has been established to measure its impact on the final outcome of the SEM model:

H_{01}: 'Supply chain supporting factors' does not affect the production performance of dairy supply chain.

The 2nd factor labelled as 'Strategy & human resource management' accounted for 13.83% of the variance. 4 statements describing the factor, having the factor loadings of 0.669 to 0.791 were encompassed (Table 2). The factor draws relevance from the statistical point of view as well as the literature. Based on the second factor drawn, following null hypothesis has been established to measure its impact on the final outcome of the SEM model:

H_{02}: 'Strategic & resource management' does not affect the production performance of dairy supply chain

The 3rd factor labelled as 'Quality management' accounted for 14.93% of the variance. 5 statements describing the factor, having the factor loadings of 0.505 to 0.782 were encompassed (Table 2). The factor draws relevance from the statistical point of view as well as the literature. Based on the third factor drawn, following null hypothesis has been established to measure its impact on the final outcome of the SEM model:

H_{03}: 'Quality management' does not affect on the production performance of dairy supply chain.

The 4th factor labelled as 'Technological innovations' accounted for 15.98% of the variance. 5 statements describing the factor, having the factor loadings of 0.704 to 0.894 were encompassed (Table 2). The factor draws relevance from the statistical point of view as well as the literature. Based on the fourth factor drawn, following null hypothesis has been established to measure its impact on the final outcome of the SEM model:

H_{04}: 'Technological innovations' does not affect the production performance of dairy supply chain.

The 5th factor labelled 'Operations management' accounted for 14.29% of the variance. 4 statements describing the factor, having the factor loadings of 0.664 to 0.823 were encompassed (Table 2). The factor draws relevance from the statistical point of view as well as the literature. Based on the fifth factor drawn, following null hypothesis has been established to measure its impact on the final outcome of the SEM model:

H_{05}: 'Operations management' does not affect the production performance of dairy supply chain.

Validity of Construct

Face Validity

It is measured by observing at the model 'on-its-face', and it presents a decent image of the production operations in current study (Trochim, 2007).

Content Validity

Content validity of questionnaire was judged over deliberations with academicians, understandings from literature and author's own knowledge, and the questionnaire was refined as per suggestions (Trochim, 2007).

Construct Validity

It is measured in three stages, as follows.

Uni-Dimensionality

The developed CFA model indicate the CFI rate of 0.9 and thus inferring a robust uni-dimensionality (Bollen and Ting, 1993; Byrne, 1994).

Convergent Validity

It deals with the degree to which diverse procedures to computing a model offers the same outcomes (Ahire *et al.*, 1996). The factors having loadings ≥0.6 (0.63 to 0.95 in current study) in CFA model demonstrate robust convergent validity (Chin *et al.*, 1996).

Discriminant Validity

It confirms the amount to which a model and its statements vary from others (Bagozzi *et al.*, 1988; Fornell and Larcker, 1981), and it was calculated by the 'StatToolPackage' proposed by Prof. James Gaskin. The square root of AVE of individual factor, diagonal cells, is greater than the correlation constant of a factor with others in non-diagonal cells (Table 4), and thus indicting a robust discriminant validity of the developed model.

Table 4. Discriminant validity for CFA model of production operations

	Quality_Mgt.	SC_Support	Strategic_RM	Tech_Inno.	Opr_Mgt.
Quality_Mgt.	**0.783**				
SC_Support	0.775	**0.815**			
Strategic_RM	0.722	0.692	**0.809**		
Tech_Inno.	0.380	0.331	0.421	**0.701**	
Opr_Mgt.	0.755	0.704	0.669	0.328	**0.734**

Predictive Validity

It is recognized when a standard exterior to the model is associated with factor structure (Nunnally, 1978) and is judged by Pearson correlation, where all correlation numbers were found positive at 0.05 significance level, and thus assuring the predictive validity of developed model (Table 5).

PRODUCTION MODEL

After verifying the validity and reliability of the CFA model, a final model has been developed to assess the production performance by linking the CFA model with the four outcome variable. The outcome variables have been considered with the consultation of experts from academics and dairy industry sector. Relevant data has been collected from 265 participants for the outcome variables. The selected outcome variables for measuring the production performance are as follows.

Table 5. Correlation for CFA model of production operations

Dimension	Correlation with Production operations
Supply chain supporting factors	0.612*
Strategic & resource management	0.694*
Quality management	0.620*
Technological innovations	0.663*
Operations management	0.701*

*Significant at 0.05 level (2-tailed).

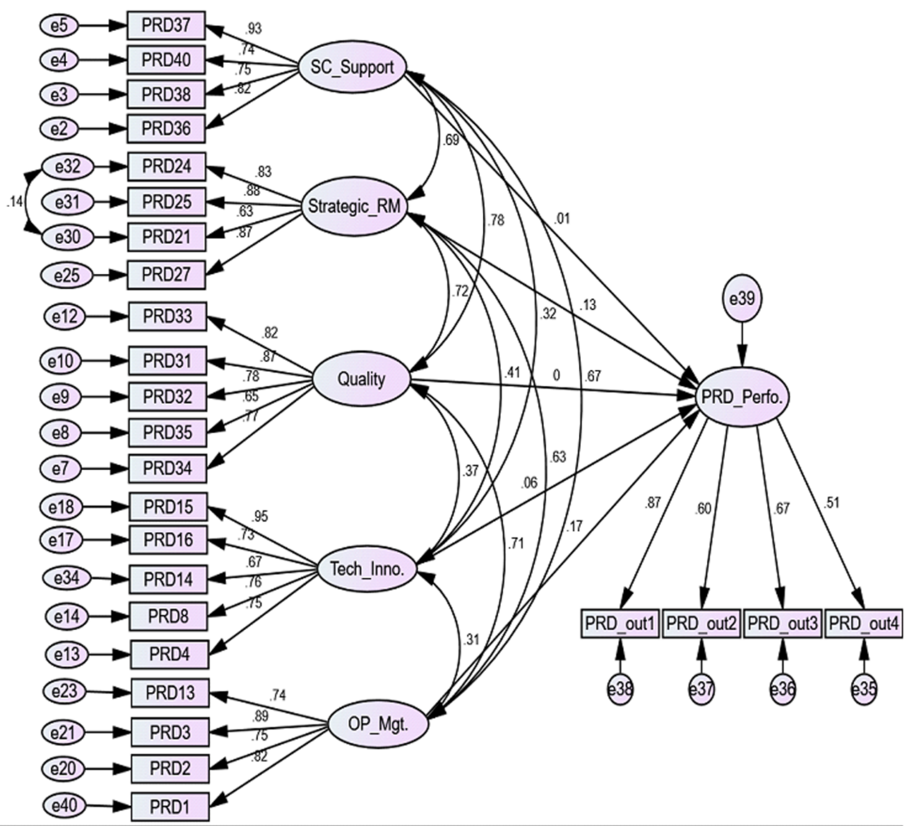
- **PRD_out1:** Reduction in setup time, unplanned breakdowns, overall production cost and overhead expenditure
- **PRD_out2:** Level of infrastructure & innovations in production system
- **PRD_out3:** Flexibility in production system
- **PRD_out4:** Overall productivity of production system

The final production model consisting of the five factors (with 22 statements) and the four outcome variables defines the production performance in dairy supply chains (Figure 3).

Validity of Model

The model validity is evaluated as follows.

Figure 3. SEM Model development for measuring Production Performance



Discriminant Validity of Model

Discriminant validity was calculated by the 'AMOS Plugin' and 'StatToolPackage' proposed by Prof. James Gaskin. All the respective values of MSV are lower than AVE, all the AVE values are >0.5, and CR is more than AVE (Table 6). Reference to the thresholds given by Hu *et al.* (1999), all the values are within limits. Hence, no validity concerns here in the proposed production model.

Model Fit Measures

The model fit measures have been calculated by the 'StatToolPackage' proposed by Prof. James Gaskin. All the respective values come out to be as: CMIN/DF: 2.236, CFI: 0.919, SRMR: 0.052, RMSEA: 0.068, and PClose: 0.055. Reference to the thresholds given by Hu *et al.* (1999), and Gaskin *et al.* (2016), all the respective values are within the specified limits (Figure 4).

Table 6. Discriminant validity for measuring production performance

	CR	AVE	MSV	MaxR(H)	Quality_ Mgt.	SC_ Support	Strategic_ RM	Tech_ Inno.	Opr_ Mgt.
Quality_ Mgt.	0.823	0.522	0.502	0.901	**0.722**				
SC_ Support	0.820	0.532	0.502	0.952	0.776	**0.729**			
Strategic_ RM	0.824	0.526	0.523	0.967	0.723	0.693	**0.725**		
Tech_ Inno.	0.840	0.508	0.167	0.978	0.372	0.319	0.409	**0.713**	
Opr_ Mgt.	0.826	0.521	0.508	0.981	0.713	0.668	0.632	0.306	**0.722**

Ref.: Hu *et al.* (1999); Gaskin *et al.* (2016).

Figure 4. Model Fit measure for measuring production performance
Ref.: Hu et al. (1999); Gaskin et al. (2016).

Measure	Estimate	Threshold	Interpretation
CMIN	632.817	--	--
DF	283	--	--
CMIN/DF	2.236	Between 1 and 3	Excellent
CFI	0.919	>0.95	Acceptable
SRMR	0.052	<0.08	Excellent
RMSEA	0.068	<0.06	Acceptable
PClose	0.055	>0.05	Acceptable

Hence, the developed model is acceptable for measuring the performance of production operations in dairy industry.

Hypotheses Testing

The primary objective of SEM is to study the validity of hypothesized model by identifying and estimating the linear relations between a set of observed & unobserved variables (Panuwatwanich *et al.,* 2008). The hypotheses tested in SEM are often more positive in nature and considered as much more definitive than other correlational analyses methods (Collis and Rosenblood, 1985; Crosbie, 1986; Cudeck and O'Dell, 1994; Larzelere and Mulaik, 1977). The hypothesis has been tested in this section of the chapter. Here, predictors are the five factors drawn during EFA (Table 1) and the outcome indicates the outcome variable for the SEM model, and S.E. is the standard error. The values of C.R. (critical ratios) and p values (Table 7) all the critical ratios are >1.96 (95% confidence) and p values <0.05 signifying as significant. Thus, all five factors positively influence the performance of production operations in dairy supply chain and the null hypotheses designed for the current study are now rejected.

Further, to bring out the order of importance of five factors comprising various statements for measuring the production performance, the regression analysis was performed by considering the ratings of production operations as the dependent variable and the mean scores on the five factors as independent variables. The standardized coefficient beta (β) of the individual dimension represented their importance (Parasauraman *et al*., 1985, 1988), Figure 4. The results clearly show the significance of the overall regression model ($p < 0.05$), with 72.16% of the variance in production operations explained by the independent variables. The significant

Table 7. SEM Model for measuring production performance

Sr. No.	Outcome	Predictor	Estimate	S.E.	C.R.	p Value	Status	Order of importance
1	Production Performance	Supply chain supporting factors	0.248	0.087	6.090	***	Significant	4
2		Strategic & resource management	0.172	0.076	5.040	***	Significant	5
3		Quality management	0.305	0.061	5.620	***	Significant	2
4		Technological innovations	0.263	0.039	4.810	***	Significant	3
5		Operations management	0.391	0.086	3.434	***	Significant	1
*** p < 0.05								

factors that remained in the equation in the production operations and are shown in order of their importance based on a standard estimate or β coefficient. Higher value of standardized β coefficient helps in contributing more to explain the dependent variable (Lee *et al*., 2000). The factor 'operations management' appears to be most vital followed by the others as quality management, technological innovations, supply chain supporting factors, and the strategic & resource management to be least important.

Significance of Results

The current study develops the model for production operations and proves its practicality for the dairy professionals. Once developed, the SEM model for managing the production operations could be used by the researchers and dairy professionals, as follows.

1. The intuitions of current study will aid the researchers and managers in getting the issues of production operations in dairy industry.
2. The model offers five dimensions to measure the production performance in dairy industry viz. quality, innovations, operations, resources, and other factors supporting the dairy supply chain.
3. The scores on individual statements illustrate the proposals for improving the production operations.
4. The results of hypotheses testing suggest that all five factors positively influence the production performance. The developed model can also be used as an analytical tool to analyze the production performance and benchmark it across different milk unions or milk processing units.
5. An incentive-based system can be recommended to improve the production capacity, process quality, wastages etc. and hence, to improve the production performance.

CONCLUSION

The current research aims to evaluate the production performance of Indian dairy industry. Secondly, it aims to develop the framework for measuring the performance of production operations in dairy supply chains using SEM techniques. So, the study examines the production operations from a theoretical as well as validation viewpoint which is intended at developing a structural model in a real-time industrial scenario.

A survey was conducted in various Indian dairy industries. 22 statements related to dairy production operations were considered for factor analysis. The outcome of factor analysis reduced the statements into five factors viz. supply chain supporting factors; strategic & resource management; quality management; technological innovations; and operations management. The relative importance of the factors has also been carried out based upon the standardized beta (β) value. Out of five factors, 'operations management' seems to be most important (β= 0.391) afterward quality management, technological innovations, supply chain supporting factors, and strategic & resource management (β= 0.305, 0.263, 0.248, 0.172) in their respective importance. The final production model has been developed after verifying the reliability (α), and convergent validity (factor loadings ≥0.6), discriminant validity (AVE >0.5) & predictive validity (correlation constant positive at 0.05 level) of model. Finally, the SEM model has been developed by linking the CFA model with four outcome variables. The SEM model was checked for discriminant validity (AVE >0.5, CR >AVE) & model fit indices (CMIN/DF: 2.236, CFI: 0.919, SRMR: 0.052, RMSEA: 0.068, PClose: 0.055), and authors found the model within specified range recommended by Hu *et al.* (1999), and Gaskin *et al.* (2016). The hypotheses testing (p <0.05) suggest that all the five factors positively affect the production operations, and hence, the model is adequate for measuring the performance of production operations in dairy industry.

The outcome of the current analysis shows that the overall production performance in dairy supply chains can be analyzed through the proposed factors & sub-factors. Managing the five factors will help dairy industry in reducing the setup time & unplanned breakdowns, lower overall production cost & overhead expenditure; achieving flexibility in the production system, and hence, the enhanced productivity. The major production issues like abnormal wastage, manual operations, and infrastructural issues should be put in the limelight. Thus, the proposed framework will help managers in the dairy industry to manage the production operations through technological innovations, process management, and execution of effective information systems.

Limitations and Future Scope

The proposed model can be further generalized for other dairy industries across the region. The cause and effect relation could not be derived here. Other interfaces of supply chain i.e. procurement, distribution etc. may also be explored using the same methodology. Further, the procedure can be executed on the other fresh food processers also.

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Chapter 3
Managing Relationships With Suppliers:
The Case of a Local Subsidiary of a Global Company of Components for the Automotive Industry

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ABSTRACT

In recent years, growing market competition has made companies increasingly dependent on their suppliers, which requires effective management of their supply chains. To establish and maintain relationships with the best suppliers, companies apply strategic supplier selection, evaluation, and development criteria. The literature review showed the importance of supply chains and the use of strategic criteria in managing relationships with suppliers. Based on the model proposed by Oflac, the authors studied a local subsidiary of a global company of components for the automotive industry. Through this case study, it was possible to understand how a firm establishes strategies and performs in the practice its supply relationship management activities. Results suggest that the existence of strong and continuous relationships creates advantages for companies, allowing them to remain competitive in the markets. The strategies of selection, evaluation, and development of suppliers enable companies to filter the best partners and develop their capabilities to achieve greater profits.

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INTRODUCTION

With the rise of globalization, markets have become more complex and competitive. Accelerated competition has resulted in new products and services. Customers are nowadays more informed and demanding, requiring companies to constantly innovate in order to create and sustain the competitive advantage (Carvalho et al., 2012). Supply chains have a critical role in the way companies are organized and establish relationships (Choy & Hartley, 1996). Companies no longer compete between themselves; they compete between their supply chains (Lambert & Cooper, 2000). Companies nowadays do their purchases globally. This allows them to extend their suppliers and customers' networks, facilitates the access to new markets and technology, leading to better products and better quality, and allows them lowering prices and reducing delivery times (Hines, 2004). In today's world, relationships play a key role in supply chain management. For supply chains to stay competitive and work efficiently, it is essential to select the best partners and manage relationships effectively (Liker & Choi, 2004).

Companies focus more on their products and on what they are good at, leaving a substantial part of their value chains to their suppliers (Liker & Choi, 2004). This increases the importance of the suppliers in the company's success. This tendency seems to reduce the supplier base, driving companies establish long-term relationships with the best partners (Lambert, Cooper, & Pagh, 1998). Suppliers have therefore a great impact on companies, so it is very important for companies to create effective strategies to select and manage their suppliers. According to Kannan and Tan (2002), accurate management is based on three dimensions – suppliers' selection, suppliers' evaluation and suppliers' development. Each company ought to apply these strategies according to its goals and needs.

According to Betchel and Jayram (1997), the future of supply chains is based on the establishment of partnerships, strategic alliances and cooperative relationships. Supply chains are connected to relational factors rather than transactional factors, and relationships are very important for the proper functioning of supply chains. Lamberts, Cooper, and Pagh (1998) refer to relationships as a crucial element of a supply chain. However, cooperation and coordination between all the intervenients of the supply chain are essential for the success of the relationship. Mentzer et al. (2001) argue that in order to create competitive advantage and become more efficient supply chains need to work together, share information, risks and profits, and focus on the client.

Relationships between customers and suppliers have been changing over the years. In the early seventies, the main criterion was the price. Companies used a large base of suppliers and the competition was happening between them. For companies, this required a lot of resources and time. Then, with an increase in the global competition, companies became more demanding with their suppliers and more selective towards their business relationships. Price is no longer the single criterion, and quality started to gain importance in the supplier's decision. In the eighties, companies began to realize the advantages of cooperative relations. Although the price was still a relevant and differentiating factor, others such as quality and delivery gained greater emphasis. Companies started to focus on exchanging information with their suppliers, improved communication and introduced new techniques in order to increase products quality (Langfield-Smith & Greenwood, 1998). In the nineties, companies were focused on developing close relationships with their suppliers. This meant working with a smaller number of suppliers and choosing those that offered better products, delivering time, and, in general, better service. High switching costs fostered networks within the supply chain and promoted further relationships based on trust (Langfield-Smith & Greenwood, 1998). This model is still in use nowadays to pursue competitive advantage. Doing business with a smaller number of suppliers allows reducing the price of transportation, achieving economies of scale and better prices overall. It also leads to greater involvement of suppliers, new product development, improvement of existing products, as well as increased cooperation and flexibility (Shin et al., 2000).

This chapter focus on understanding how companies in the automotive industry manage relationships with their suppliers. With the globalization and increasing competition, relationships start to have a greater impact on the way companies do business, fostering long-term relationships with suppliers. The research aims to demonstrate how companies select and evaluate suppliers, and how they strive to establish partnerships in a real context. Based on the literature review, the case of a local subsidiary of a global company of components for the automotive industry was studied in order to understand how this local company (hereby referred as Company X) applies the selection, assessment and development strategies of its suppliers.

Supplier Selection Process and Relationships Management

Suppliers' Selection

The supplier selection process is very important for the companies as it influences the quality of the products and their competitiveness in the market. Over the years, there have been changes regarding the supplier's selection criteria used by companies. Initially, price prevailed in supplier selection; however, with increasing competition, other criteria began to gain relevance in the decision process, more specifically, quality and delivery. These two factors have a direct impact on the product and constitute decisive criteria in the partner selection process. Some other criteria additionally help companies to differentiate their suppliers, such as: the service provided, production capacity, technology used, cultural or risk factors, financial capacity, among others (He, 2014).

Oflac (2015) pointed out the following criteria as the most important for a company when choosing a supplier: price, delivery, quality, management compatibility, development and training, product credibility, attitude, strategy, work relationships, technological capability, after-sales service, communication and information systems, financial status and innovation. One of the most used methods in selecting suppliers is the multi-criteria method. It allows companies to select the criteria according to their strategy and area of activity. Through this method, it is possible to cross-analyze the alternatives that meet these criteria. The final selection decision can be continuously evaluated as necessary (Bedey et al., 2009).

Suppliers' Evaluation

As the suppliers have a direct impact on the company's performance, it is vital to evaluate constantly their work. This process allows companies to identify suppliers' strengths and weaknesses. The automotive industry is no exception, in particular for companies that supply automotive components suppliers become a key factor, as their final product incorporates items from their suppliers (Fredriksson and Gadde, 2003). In order to assure that the products bought from their suppliers fulfill all the requisites, companies monitor their suppliers and their performance. This will enable them to recognize and anticipate problems in order to minimize the number of failures and to improve the capacities of the suppliers, further reflected in improvements for the company (He, 2014). During the supplier evaluation, companies focus on more relevant aspects that will affect their performance, such as: quality, price, technology and innovation, or flexibility of the supplier and on efficient deliveries. All these factors have a direct influence on the product the companies deliver to their customers, and should, therefore, be taken into account when evaluating suppliers (Bedey et al., 2009).

Minahan and Vigoroso (2002) define the supplier evaluation system as a process for analyzing and monitoring supplier performance, whose objective is to achieve continuous improvement and to minimize the associated risks and costs. These authors identify four strategies that will allow companies to achieve better results in terms of supplier performance measurement: (1) to evaluate the performance of all suppliers; (2) to have a standard procedure to measure supplier performance; (3) to work with suppliers to improve their performance based on the evaluation result; and (4) to have automated processes to measure suppliers' performance.

After the supplier evaluation process, the results must be assessed so that actions can be implemented. Some companies choose to share the results with the suppliers in order to achieve continuous improvement. This allows them to identify opportunities to improve and minimize failures creating healthy competition among suppliers and encouraging them to improve their performance (He, 2014). Whether the supplier has received a positive or a negative assessment, there are always elements that can be improved and developed. Suppliers with highly positive results need to stay motivated, so they can continue presenting good results. In order to do so, companies reward those who deliver the best results. Benefits may include the creation of a reward system, investing in supplier R&D, or creating alliances (Oflac, 2015). Although these suppliers may not have the most competitive prices, it is important to keep them and establish long-term relationships thank their exemplary performance (Minahan and Vigoroso, 2002). For the suppliers with average results, it is important to identify failures and opportunities for improvement, to support them and to develop their capacities in order to achieve better results in the future (Oflac 2015). For the suppliers with the weakest results, targets must be established and corrective actions must be taken in order to avoid certain failures in the future. If necessary, companies should perform audits to determine the reasons that have led to poor performance. In the case of no improvement or interest in such, the existing contract can be terminated (Oflac, 2015). Companies may also choose do not do business with these suppliers until their failures have been corrected and their performance improved (Minahan & Vigoroso, 2002).

Oflac (2015) identified eight criteria to select and evaluate suppliers: quality, price, logistic capacity, information sharing, trust, contractual terms, social and environmental responsibility, and innovation. These categories are based on the importance they have for the companies. After the evaluation in each one of these categories, suppliers obtain the final score, from which it might be easier to outline development strategies.

Suppliers' Development

Along with continuous evaluation, companies choose to develop their suppliers in order to improve their performance and capacity so they can respond to the company needs and anticipate possible problems that may arise (Bedey et al., 2009). Companies are increasingly committed to long-term relationships and prefer to invest in developing suppliers' capacities according to their requirements. Hines (2004) emphasizes the importance of supplier development programs to achieve beneficial solutions for both parties, highlighting improvements that the use of these programs can bring to the supply chain. According to this author, companies should be able to select the appropriate suppliers for the implementation of development strategies, to identify the capabilities of the suppliers that respond to their business needs, to create performance evaluation systems and to share them with the suppliers, as well as to establish trust and commitment in the relationships with them.

In a study conducted in 1990, Hahn, Watts and Kim identified the steps that should be followed during the supplier development process. To decide about a supplier development strategy is necessary to take into account the supplier's assessment score. Based on the results, it is important to identify the nature of the problem, the weaknesses and what can be improved, and determine the development measures, which must be accepted by both parties. After implementation, it is necessary to evaluate the output achieved with the new measures and check if the objectives were reached. If suppliers fail to meet targets, the company must consider excluding them from the supplier base.

Scanell and Vickery (2000) consider the development of suppliers important and defend that companies should work with them to help them develop their own capabilities. To achieve this, both parties must cooperate and be proactive, establish long-term committed relationships, integrate their processes and share benefits, establish common goals and improve activities and processes.

Partnerships

When establishing partnerships, companies consider their importance and potential benefits. Ellram and Edis (1996) define buyer-seller partnerships as cooperative approaches in which a company works together with several suppliers in order to obtain mutual benefits, sharing risks and benefits. This cooperative relationships lead to better performance and creates competitive advantages for the involved parties. According to Krause and Ellram (1997), most companies that implement supplier development strategies pay close attention to their relationships with suppliers and consider them as partners. Companies invest in supplier development strategies because relationships with them are seen as worthy of such investment. Communication and collaboration become essential to understand the other side expectations and work towards common goals. Through the development of partnerships within the supply chain, the parties involved enter in relationships of interdependence and joint benefits. This can imply lower costs, value creation and competitive advantage over their competitors, increasing customer satisfaction and meeting their needs and requirements (Mentzer et al., 2001) Wisner and Tan (2000) emphasize potential benefits of partnering, such as improved performance, access to better technology, higher quality products, reduced inventories, or greater flexibility in markets. Through partnerships, companies are able to introduce their products in the markets more quickly and efficiently (Hines, 2004).

Relationships between suppliers and buyers begin as transactional relationships and develop over time when parties invest, cooperate and develop trust. Duffy and Fearne (2004) distinguish between transactional relationships and partnerships, indicating that although buyer-client relationships begin as transactional, they will progress and strengthen over time to become partnerships.

Supplier-buyer relationships usually focus on the long-term. Companies reduce their supplier base and focus on developing their own suppliers. As communication and information sharing improves, the process starts to be integrated and coordinated between both sides. Activities are performed together as well as the decision-making process, turning relationships win-win orientated (Dutty & Frame, 2004). Sometimes, maintaining the partnership turns out to be a difficult task due to the differences that may arise between partners. Often, it is necessary to make adaptations according to the needs of both parties, whether adaptations to the product, the process or even the behavior (Cannon & Perrault, 1999).

Study Design and Methods

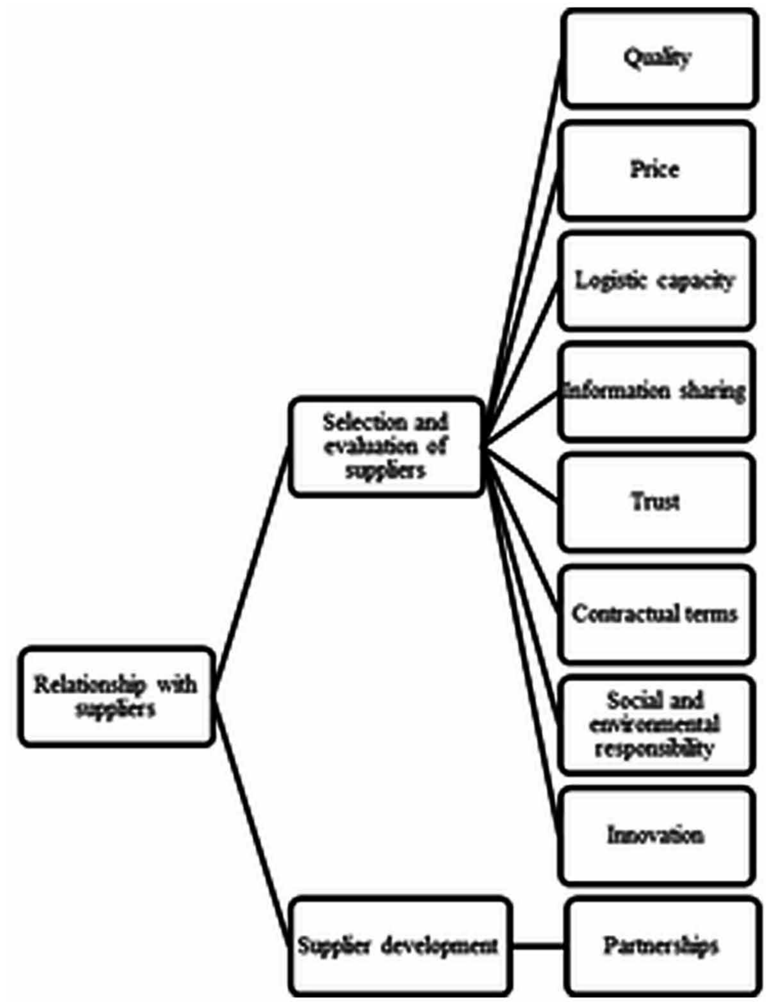
This study focus on the specific case of a local subsidiary of a global company of components for the automotive industry – the company X. It analyzes policies and strategies for suppliers' selection and management, and the efforts and strategies that the company implements to develop good relationships with suppliers. In the automotive industry, components acquired from suppliers represent a substantial part of the final product that the company delivers into the market. Hence, it is important to establish close relationships with suppliers to achieve product quality standards. In this context, some research questions guided the study:

- How do relationships with suppliers affect the performance of companies operating in the global market?
- How do these companies manage their relationships with suppliers?
- What kind of strategies do companies develop to establish and maintain relationships with their suppliers?

The research questions offered direction for proposing a system of categories and subcategories of analysis based on the literature review that served as the guidelines for analyzing the case. The main categories of analysis are: (1) supplier selection and evaluation strategies and (2) supplier development. Several subcategories of analysis emerged from the first category, more specifically, factors that influence the process of suppliers' selection and evaluation. The second category focused on the relationship between the development of suppliers and the establishment of partnerships with them (see Figure 1).

For the selection and evaluation of suppliers, the study used the criteria proposed by Oflac (2015). The existence of a link between suppliers' development

Figure 1



and partnerships creation was supported by the literature, which indicates the interdependence between these two strategies.

The study applies this theoretical framework to the analysis of a company that produces components to the automotive industry, with the purpose of learning from its specific context how Company X select suppliers, manage relationships with them and implement development and evaluation strategies. As the research intended to study a phenomenon in its natural context, with little available knowledge, a qualitative approach has been applied (Njie & Asimiran, 2014), using a case study methodology. Data collection included in-depth interviews, direct observation and analysis of secondary information provided by the Company X or available in its partner portal. The interview guide reflected the categories and subcategories of analysis.

The company's purchasing department is responsible for establishing and managing the relationships with suppliers, which includes supplier selection, evaluation and development processes. Three professionals, with different responsibilities and roles, from the purchasing department of Company X, participated in the study:

- Participant 1: Director of the purchasing department;
- Participant 2: responsible for supplier selection and negotiation;
- Participant 3: responsible for supplier evaluation and development area.

Given the roles that these three participants perform in the company's purchasing department, their in-depth interviews provided vital information for the case study.

THE CASE STUDY

Company X

Company X is one of several subsidiaries of a Germany-based global group that has now more than 100 years of experience in the market and is a pioneer in innovation. Established in 1991, in Portugal, Company X focuses its activity on the automotive sector. It is dedicated to the manufacturing of automotive components, and the development of access, safety and immobilization systems for the automotive industry.

Company X establishes its relationships with suppliers through the purchasing department, which consists of two areas: supplier selection and negotiation, and supplier evaluation and development. Its mission is to establish partnerships and to ensure that suppliers meet the company's quality requirements. Thus, the main activities of the department are directed to build and maintain long-lasting relationships with partners.

Internally, Company X uses interconnected processes to approach its supply chain management. Some of the company's departments provide services and information to other departments and there are departments that are costumers of other departments. Hence, "joint work is essential" (Participant 1, personal communication, April 19th, 2017). Company X relies on an ERP system, which facilitates the flow of internal information and allows for an integrated information system. There are other available resources for information flow: a weekly agenda sent to all employees that provides general information about the company; a monthly meeting with all department directors, and a quarterly meeting with the area management and all employees that addresses the current situation of the company and future prospects. It is possible to see that communication plays an important role for Company X, which values information exchange and transparency and considers them essential for good internal functioning (Participant 1, personal communication, April 19th, 2017).

To achieve trustful and long relationships with its suppliers, Company X strives to develop win-win relationships, in which both parties benefit. In the endeavor to foster good relationships with suppliers, to solve problematic situations involving suppliers is seen as priority activity (Participant 1, personal communication, April 19th, 2017).

Only recently, suppliers have started to be involved in the process of new product development, something that Participant 1 (personal communication, April 19th, 2017) relates to business evolution, which increasingly requires an active participation of the entire supply chain, leading to a greater integration of processes at the level of the supply chain. Currently, Company X makes efforts to include its suppliers at an early stage of the development of new products. Although in some situations product specifications are defined by the customer without the possibility of change, there are products in which suppliers can make suggestions for product improvement and actively participate in the product development.

Company's policies further demand that suppliers should not only depend on Company X. One of the corporate rules states that the supplier turnover should not exceed 30%. Likewise, the company avoids having all the costs with one only supplier. In average, for each group of materials, the company uses four to five suppliers.

Supplier Selection Process

To achieve good performance in the sector, it is necessary to work with the best partners. As 70% of the final product produced by Company X includes materials from suppliers, supplier selection plays an important role in the company business. Selecting the best suppliers in the market and establishing relationships with them in order to create high quality and competitive products is crucial (Participant 1, personal communication, April 19th, 2017). Currently, the process of supplier selection at Company X is conducted together with other companies of the group at a European level. A supplier portfolio, managed by the global purchasing department, is available to the subsidiaries of the group. Although the global purchasing department is responsible for managing the supplier portfolio, all the companies in the group participate in the portfolio management and review process, through an annual meeting with the participation of all the local purchasing directors. The meeting allows analyzing and evaluating suppliers in the portfolio and suggesting including or excluding some of them. Performance and responsiveness towards problems and supplier's appraisal constitute decisive factors for suppliers evaluation at this stage and, consequently, for their permanence in the portfolio (Participant 2, personal communication, April 19th, 2017).

By reducing the number of suppliers, the company is able to standardize the work and to guarantee a closer follow-up of the suppliers. When a supplier enters the portfolio, the goal is to start growing within the group over time (Participant 1, personal communication, April 19th, 2017).

The portfolio is divided into groups of materials and suppliers assigned to the groups. The same supplier may belong to several groups of materials (Participant 2, personal communication, April 19th, 2017). In order to integrate the supplier portfolio, a supplier must comply with a number of criteria required by the company. They comprise the following factors: competitive price; solid structure and financial stability; certifications (ISO 9001, ISO/TS 16949 e ISO 4001); to have a global footprint; to have technical knowledge; to be proactive; to innovate; and to be flexible. These aspects are important to implement improvements to the processes and products, and are able to result in a reduction of time or costs. In addition, to the combination of these criteria, there are a number of procedures to be followed prior to the integration of a supplier into the portfolio. Firstly, the company sends a questionnaire to the supplier with a request of all the information and certificates. The information is analyzed by the group and a confidentiality agreement is signed between both parties. Based on the information s and certifications showed, it may be necessary to audit the supplier in order to inspect the production, logistics and financial capacity. Supplier financial ratios and certifications are also analyzed (if the supplier does not have ISO TS certification, the audit will be repeated every three years). The group headquarters have access to the final report, which if approved, the supplier is included in the portfolio (Participant 1, personal communication, April 19th, 2017).

Supplier Evaluation

The evaluation of suppliers has always been a very important tool for Company X. Given the impact that suppliers have on the final product, it is necessary to evaluate their performance in order to understand what improvements are necessary. Supplier evaluation is performed monthly and annually, the latter by a compilation of all monthly assessments. The supplier evaluation process is carried out in the same way by the global purchasing department, for all companies in the group, through a common database. The logistics and quality departments have also a relevant role in the suppliers' evaluation process (Participant 3, personal communication, April 19th, 2017).

Every month, Company X organizes a meeting called short-term monitoring, with the purchasing, quality and logistics departments. The main objective of the meeting is to discuss and analyze questions related to supplier evaluation and to define implementation of measures to develop suppliers. Supplier evaluation process englobes all suppliers; however, there are some differences within them. At the beginning of each year, the global company defines targets for suppliers, according to the groups of materials they are assigned, that are communicated to them. In addition, Company X determines key suppliers which are those with strategic importance for the company, requiring, therefore, a closer follow-up and a smaller margin of error.

Since 2015, supplier evaluation in the global group is based on two criteria: quality and logistics, each of them further divided into sub-criteria. Regarding quality, the company makes its evaluation based on PPMs (Parts Per Million) and a number of complaints, and how suppliers manage the 8Ds. In what concerns to logistic, the company evaluates the deliveries – whether they are correct and done within the agreed time. The data regarding supplier evaluation and the results are available to all the suppliers through the group's partner portal. Suppliers have access to their performance evaluation. Until 2015, each subsidiary of the group was allowed to decide how to perform its supplier evaluation without the need to follow the group guidelines. The supplier evaluation approach of Company X used to be wider. In addition to quality and logistics, Company X considered other criteria, such as commercial aspects and project management.

Supplier Development

Following the supplier evaluation and based on its results, Company X implements development strategies for their suppliers. Since the performance of suppliers and company are clearly related, the company works toward improving suppliers' performance.

Implementation of supplier development methods comes after supplier evaluation and identification of improvement opportunities. Initially, targets are established so that an agreed action plan can be drawn up with the supplier. Afterward, previously defined measures are implemented. After the final analysis, the process is closed. This process is of the responsibility of the purchasing department of Company X, which is also responsible for identifying the areas and ways of improvement. A negative assessment of supplier, lack of compliance in quality requirements of Company X, non-compliance with improvement strategies agreed between the supplier and Company X or poor supplier's performance are the main reasons that frequently leads to the need for change and improvement. Suppliers' development process is concluded as the defined targets are reached and confirmed by Company X. Applied strategies may vary depending on the number and type of complaints regarding the supplier, the period of time in which they have occurred, or their impact in the production level. Therefore, the need for their implementation might have to be immediate.

The suppliers' development process of Company X can be divided into several phases, named supplier support and ranging from 1 to 4. The higher the level the higher the need for support. All these phases are monitored by the purchasing department. The initial phase - supplier support level 1 - consists of defining a plan of action to face the identified problem. If the supplier performance improves after the implementation of the action plan, it is not necessary to proceed to a subsequent phase. If improvements cannot be reached regardless of the support implementation, supplier support level 2 is activated. At this stage, the actions involve meetings with the supplier at Company X or visiting the supplier facilities in order to understand why actions are not leading to improvement. Regarding supplier support level 3, it may be necessary to perform an audit to the supplier facilities and to ensure that the measures defined in supplier support level 1 have been implemented correctly. When none of the above solutions offers positive results, the purchasing department of Company X together with the supplier try to find solutions to ensure the continuity of the partnership (supplier support level 4). In the case of an agreement is not possible to be reached or the supplier is unable to fulfill the agreed objectives, Company X has to stop working with this supplier.

Quality

Similarly to what is happening in the automotive industry worldwide, Company X is highly concerned with the quality of the products and materials it purchases from its suppliers. Thus, product quality is on the top of criteria when selecting suppliers. In order to obtain quality assurance, the company requests the suppliers quality certificates used in the automotive industry (such as ISO TS 16949). When the selected supplier does not have such certification, the only way to enter the company's portfolio is a positive approval in an audit. Company X also requires from its suppliers to present the PPAP (Production Part Approval Process) documentation to ensure that they comply with the procedures and techniques used in the automotive industry. Throughout the lifetime of the project, Company X controls the number of PPMs and 8D complaints. These procedures aim to identify and correct failures as well as to reduce the number of rejected parts.

Price

For company X, the price is another important criterion when selecting suppliers. It is usually used to help differentiate proposals from different suppliers. During the negotiation process with suppliers, company X negotiates price discounts in the project. This means that during the lifetime of the project, an additional discount per year is negotiated, which is usually 3% in the first year, and more 3% in each following year. This discount can be applied to the entire project, or only to the manufacturing process, excluding the material.

Logistic capacity

The respect of deadlines by suppliers is essential for the company can deliver products on time to customers. Therefore, when selecting suppliers into the company portfolio, the logistic capacity of the supplier is assessed, and if necessary logistic audits are carried out. Subsequently, when selecting a supplier for the delivery of a given part, the terms of delivery are agreed between the parties, and the supplier commits to meeting the company's requirements.

Logistic capacity is one of the most important criteria in supplier evaluation as well. The fact that the margin of error or delays is low means that there is strict control over these criteria. The main points assessed at the logistics level are the number of deliveries within the stipulated time and the number of correct deliveries. Suppliers must ensure that they send the material requested by the company, without errors, correctly packaged and within the requested deadlines. These criteria are considered when the company sets supplier firm targets.

Communication and Information Sharing

The group offers a partner portal to suppliers, which allows them to access the group's databases. Through this platform, suppliers can visualize their performance and review information on monthly evaluation. At the logistics level, communication between the logistics department and the company suppliers is carried out through EDI, a software that allows for fast communication, promising a low error level. In addition to the databases, Company X uses other means to contact suppliers, such as e-mail, telephone or personal contacts, through meetings or company visits.

Although communication and information are criteria of great importance for the success of a business, they are not considered a decisive factor for the selection and evaluation of suppliers by Company X.

Trust

Establishing and maintaining long-term relationships, mutual trust and reliance are fundamental. In order to build and nurture trust, partners must see the relationship as important for the business, duly fulfill agreed obligations and make an effort toward future work. For suppliers, this comes down to delivering quality products in contracted quantities and within contracted deadlines, providing support in solving problems quickly and efficiently and ensuring customer satisfaction. Company X, on the other hand, puts efforts to comply with its commitments, that is, terms of payment, only making a quality claim when a problem exists, do not penalize suppliers without a valid reason and trying to keep the same persons in the interactions with the supplier throughout the relationship with it.

Although the participants in the study consider trust highly relevant for a beneficial relationship with a partner organization, this criterion is not used for the selection and evaluation of the company's suppliers.

Contractual Terms

Company X establish confidentiality agreements with its suppliers, which is an essential factor for further collaboration. The group believes that all agreements, even those expressed verbally, should be formally stated and signed by the involved parties. In order to integrate the company's portfolio of suppliers, the supplier must accept the agreement proposed by Company X. After inclusion in the portfolio, and for guarantee contracts, the parties must reach an agreement, and suppliers must accept all the contractual terms. Therefore, this criterion has an impact on the supplier selection level. However, the same criterion is not considered at the supplier evaluation level. If the supplier does not accept the contractual terms, it will not be able to do business with the company, so it will never be a target of evaluation.

Social and Environmental Responsibility

Company X is known for its social responsibility policies, which is also a factor that the company values in suppliers. The company feels responsible for the impact that its activity has on society, integrating economic, ecological and social aspects into the business. When signing the contracts with suppliers, the company prioritizes those able to comply with sustainability requirements. Environmental issues are also taken into account at contractual level. Suppliers must comply with the requirements of the automotive industry. Company X values suppliers that have environmental certification and deliver products and services in accordance with national and international environmental regulations.

Social and environmental responsibility is important for Company X mostly because it may represent a competitive advantage to the company. It may be a relevant factor in the phase of supplier selection and portfolio constitution; however, it may not be considered when suppliers are selected for a specific project, and either for supplier evaluation.

Innovation

When it comes to innovation, company X favors technologically advanced suppliers, however, still bearing in mind a balance between innovation and cost. The company does not prioritize supplier innovation; more importance is given to other factors, such as price. Although innovation may bring additional value to the proposal of a particular supplier, it is not a decisive element in supplier selection.

Supplier Development and Partnerships

Relationships with suppliers are a key issue for the company's supply chain. One of the objectives of the company is to grow together with its suppliers. This is done through collaboration between parties, which bring advantages and might result in profitable long-term relationships. The company applies strategies to develop, maintain relationships with suppliers and develop their capabilities. Company X refers to its suppliers as partners and emphasizes their importance in providing high quality and competitive products.

Table 1 summarizes the results of the case study analysis within the main categories and subcategories of analysis that guided the research.

CONCLUSION

Results of this study suggest that relationships with suppliers are of great importance for companies and beneficial relationships between companies and suppliers promise

Table 1 – Analysis synthesis

Categories of analysis	Subcategories of analysis	Interviews	Observation
Selection and evaluation of suppliers	Quality	Applied	Applied
	Price	Applied	Applied
	Logistic Capacity	Applied	Applied
	Information sharing	Not applied	Not applied
	Trust	Not applied	Not applied
	Contractual terms	Applied	Applied
	Social and environmental responsibility	Applied	Applied
	Innovation	Not applied	Not applied
Supplier development	Partnerships	Applied	Applied

considerable advantages. For the effectiveness of a supply chain, it is necessary cooperation and integration of common processes and goals (Shin et al., 2000). When analyzing the network of relationships of Company X with its suppliers, it was possible to see how important the company considers the relationships and their evolution. Beneficial relationships with suppliers allow Company X to remain competitive in the market since supplies constitute a large part of the final product delivered to the customer. The efforts and investment in managing relationships with suppliers can be therefore reflected in the products the company delivers, both in terms of quality and price. A close relationship with suppliers also fosters problem-solving capacity by establishing mutual objectives and collaboration links between the parties.

The strong competition in the global markets makes of suppliers important partners for companies with potential impact on the supply chain. At the same time, it is vital for companies to select the right partners to do business with. This implies to apply supplier selection, evaluation and development strategies in order to establish and make grow the most favorable relationships (Oflac, 2015).

Supplier selection seems a decisive strategy to screen and filter the most suitable suppliers. The results show that the process of suppliers' selection at Company X is well-established and carried out at two levels. The initial selection is made using the portfolio of suppliers that includes only the suppliers that meet the requirements. This allows Company X to management more efficiently its supply chain. When selecting a supplier for a specific project, the company considers those that belong to the portfolio, applying a set of selection criteria in order to differentiate suppliers.

The supplier evaluation process allows to analyze and appraise established business relationships. The evaluation deals with the performance of suppliers and can help identify problematic issues. Company X has been using a simplified version of the supplier evaluation model since 2015. The decision to standardize supplier management strategies within the global group resulted in the reduction of evaluation criteria turning the process simpler, although less complete. At this moment, the evaluated aspects include quality and logistics capacity. On the other hand, the fact that several departments take part in the supplier evaluation process enriches the process, allowing for the identification of aspects that are only perceived by a particular unit.

The company willingness to establish durable relationships with its suppliers leads to the implementation of supplier development strategies. Based on the results of supplier evaluation, Company X defines and applies strategies in order to develop and improve certain capabilities of its suppliers. This is a process that requires an investment of time by the company, but which is considered important for establishing partnerships. For the company, this investment can bring benefits and long-term improvements.

Regarding supplier selection and evaluation, it is important to set criteria to differentiate the suppliers and their capacities. Based on the literature review, it is possible to see that some of the criteria, such as quality, price or logistic capacity, have remained relevant over the years, while some new criteria have arisen with the globalization and development of new technologies: information sharing, social responsibility and environmental, and innovation, among others (Cannon & Perrault Jr., 1999). The analysis of the criteria applied by Company X suggests that all of them are important for the company and that they may create competitive advantages for the company. However, not all of them are considered in the decision-making process.

The use of the supplier portfolio and standard selection criteria make the supplier selection process more robust. Yet, the supplier evaluation method is rather simple. This could be improved by including more criteria in order to allow a more complete assessment of suppliers and to help identify more opportunities for improvement. However, the company supplier development process demonstrates the concern of Company X in establishing partnerships and developing and overcoming the weaknesses of its suppliers.

One of the factors that most influences the application of strategies by Company X is related to the standardization of processes at the group level, which means that all the companies that belong to the group have to equally apply the strategies of selection, evaluation and development. As mentioned by one of the participants, this standardization of processes and lack of autonomy at the local level end up conditioning the company at the strategic level.

Limitations and Suggestions for Further Research

The research presents limitations. More interviews and different participants would improve the generalizability of results. Data collection was done under specific conditions at Company X and available data was limited to one company. The replication of the study to a bigger number of companies would enhance reliability and allow getting a better insight into strategies that companies use and prefer.

Another limitation is the low number of interviews. Increasing the number of interviews within the company's employees would provide a wider perspective on how Company X manages their relationships with suppliers. On the other hand, interviews with suppliers would increase the scope of the study and enable acquiring information about strategies applied by the company, as well as the relationships between the company and its suppliers. Including also suppliers and professionals that do not work with the company would be beneficial for research. However, due to confidentiality reasons, company X did not agree to interview its suppliers. Future studies could involve these groups so that a different perspective on these relationships could be achieved.

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Chapter 4
Using Big Data Analytics to Forecast Trade Volumes in Global Supply Chain Management

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ABSTRACT

As the supply chains become more global, the operations (such as procurement, production, warehousing, sales, and forecasting) must be managed with consideration of the global factors. International trade is one of these factors affecting the global supply chain operations. Estimating the future trade volumes of certain products for specific markets can help companies to adjust their own global supply chain operations and strategies. However, in today's competitive and complex global supply chain environments, making accurate forecasts has become significantly difficult. In this chapter, the authors present a novel big data analytics methodology to accurately forecast international trade volumes between countries for specific products. The methodology uses various open data sources and employs random forest and artificial neural networks. To demonstrate the effectiveness of their proposed methodology, the authors present a case study of forecasting the export volume of refrigerators and freezers from Turkey to United Kingdom. The results showed that the proposed methodology provides effective forecasts.

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INTRODUCTION

With the rise of globalization, supply chains operations became more complex and therefore harder to manage. Nowadays, the companies not only interact with the companies within their supply chains and but also interact with outside supply chains. They also constantly compete with global supply chains. This fierce global competition increases the importance of the effective management of supply chain operations. Many supply chain operations, such as production, procurement, sales, warehousing, and forecasting, cannot be effectively designed with considering only local parameters. Today's supply chains are interconnected with global companies and supply chains, and this requires to think globally when designing and managing supply chain operations. Thus, the supply chain operations must be designed and managed with the global parameters and the effective management of global supply chain operations has become very important.

To effectively design logistics activities, the availability of accurate forecast data is crucial. For example, the effective resource allocation of a company for the distribution of its goods depends on the sales forecast data. Similarly, the quality of the sales forecast affects the performance of production scheduling and resource utilization. A good inventory management practice can help to achieve an agile response to the customer demand, however, it depends on the accurate forecast data. All these company level forecast related issues are important, but the requirement of a good forecast becomes more significant for the design of supply chain operations. In supply chain management, accurate forecasts help to streamline the operations. For example, data sharing with the other echelons of the supply chain can lead to better forecasts and help reducing bullwhip effect, which may lead to increased inventories, poor customer service levels, poor resource allocation, and wrong logistics decisions (Kabadurmus, Erdogan, & Tasgetiren, 2017). Therefore, an effective forecasting practice can reduce the inventory levels without affecting the service level and improve supply chain performance.

Forecasting in global supply chain operations is more challenging than the forecasting in local supply chains due to the complexity of the global supply chain networks. For exporters (or importers), predicting export (or import) volumes are also important since their entire supply chain operations depend on the forecasted exports. The prediction of total export volume of a country to a specific country may help to adjust their marketing strategies. If the exporting company can foresee that the total export volume would increase in the future, they can increase their production by adjusting their own supply chain operations. If they can predict that the export volume to a specific country to be reduced in the near future, they can search for alternative markets to sell their products and reshape their global supply chain operations without hindering the progress of supply chain strategies. Therefore, being able to make accurate forecasts is very important. However, in today's global and complex trade environment, forecasting has become even more difficult.

In the last fifteen years, the total exports in the world increased by more than 30 percent in value (Piezas-Jerbi & Wardyn, 2017). The major contribution to this increase has been the export of Asian countries, mainly China. However, with the increased competition, new country policies and recent trade wars, the international trade volumes can be significantly affected and accurate forecasting can become harder. In this dynamic world trade environment, the traditional forecasting tools cannot yield satisfactory results. However, with the consideration of the big data, accurate forecasts can be achieved.

For the last 20 years, the amount of data has increased significantly because of wide internet access, digitalization, and globalization. According to Chen, Mao & Liu (2014), the amount of data generated in two days in 2011 is equal to the amount of data from the start of the civilization to 2003. Today's supply chains depend on the data to design supply chain operations for reducing the cost and increasing performance (Hazen et al., 2014). In this context, "Big Data" has been one of the major topics in supply chain research. The main characteristics of big data are Volume, Variety, Velocity, Veracity and Value (Nguyen et al., 2018). The size of the data determines the volume. The different types and sources of the data indicate the variety of data. The velocity of the data is determined by the frequency of data. Therefore, only the amount of data does not refer to big data. Along with high volume, high variety and high velocity, veracity must be taken into account in Big Data Analytics (BDA) (Addo-Tenkorang & Helo, 2016). The value of the data is also significant and it can affect the impact of the Big Data Analytics. However, according to a survey performed by LaValle et al. (2011), the quality of the data is one of the main problems in Big Data Analytics applications. Big Data Analytics combines mathematical, statistical, computer science, and social sciences (Hazen et al., 2014). Machine learning, statistics, data mining, pattern recognition, optimization methods and visualization are the main tools of Big Data Analytics (Davenport & Dyché, 2013).

The most widely acknowledged big data benefits are the increased operational efficiency, better decision making, higher visibility, improved customer service and experience (Chen & Zhang, 2014; Russom, 2011; Schoenherr & Speier-Pero, 2015). Although Big Data Analytics can help reducing costs, being more agile and achieving higher service levels (Nguyen et al., 2018), according to Wang et al. (2016), less than 20% of companies adapted BDA in their supply chains due to people, culture or process related challenges (Chen & Zhang, 2014; Hu et al., 2014; Russom, 2011; Schoenherr & Speier-Pero, 2015; Villars, Olofson, & Eastwood, 2011).

Trade is one dimension of the global supply chain management that affects the operations and the performance of the supply chain. With the increased availability of wide data sources, exporters and importers can assess the progress of the trade volumes between countries and adjust their global supply chain operations accordingly. An accurate estimate of trade volumes can be achieved by simultaneously considering the market, product and time-related factors. Different countries (markets) can be compared for different products to assess different trade opportunities. Time is also important because the forecast accuracy depends on the chosen forecast horizon (e.g., monthly, quarterly or yearly). All these three aspects can be combined with the available wide data sources using Big Data Analytics to accurately forecast trade volumes between countries.

In this chapter, we present a novel methodology using Big Data Analytics to forecast the trade volumes between countries. To demonstrate our proposed methodology, the case of forecasting the export volume of refrigerators and freezers of Turkey to United Kingdom is presented. This product group is one of the main export products of Turkey, and United Kingdom is one of the main importers. Within this main product group, three different sub-product groups are tested to validate the effectiveness of our methodology and the results are discussed. Our study provides a non-parametric forecasting method using machine learning algorithms. Two different machine learning algorithms, Random Forest (RF) and Artificial Neural Networks (ANN) have been applied to forecast the export volumes. Different than the other models in the literature, our proposed Big Data Analytics approach employs more variety in data sources and machine learning features. To predict global trade data, our model employs an extensive amount of data. The results showed that our methodology provides effective forecasting for export volumes.

The rest of this chapter is organized as follows. Background Section summarizes the literature on the forecasting of trade products. In the next section, the problem is defined in more detail and the case study is given. The method to forecast international trade by using big data is presented in Methodology Section. Solutions Section reports the results of the study in detail. Conclusions and future work are summarized in the last section.

BACKGROUND

Supply chain management has been seen as a tool for gaining competitive advantage and according to Global Supply Chain Forum, one of the key processes of supply chain management is demand management (Barbosa et al., 2018). Forecasting international bilateral trade is a critical element of effective decision making for business and even for policy makers. In recent years, various forecasting models were applied for trade forecasting that uses extrapolation, time-series and economic models, agent-based computational economics models, and machine learning

(Nummelin & Hänninen, 2016). There are two mainstream research approaches, parametric and nonparametric approaches, were used in trade forecasting models. AutoRegressive Integrated Moving Average (ARIMA), Exponential Smoothing, Vector Auto Regression (VAR) and their variations are the widely used parametric time series models. To forecast U.S. merchandise exports, Dale & Bailey (1982) used Box Jenkins method. Veenstra & Haralambides (2001) studied Vector Auto Regression (VAR) to forecast the seaborne trade flow of crude oil, iron ore, grain and coal products. Seasonality in Pakistan's Merchandise Exports and Imports was studied by Akhtar (2003) by using univariate ARIMA. Again, ARIMA was used to explain spice import-export and production behaviors of India and China by Sahu & Mishra (2013). Khan (2011) studied to forecast Bangladesh's total import by using ARIMA, Holt-Winter and VAR techniques. Kargbo (2007) forecasted South Africa's agricultural exports and imports by using ARIMA, VAR, Engle-Granger (EG) single-equation and vector error-correction models (VECM). Emang et al. (2010) worked on univariate time series models to forecast Peninsular Malaysia's export demand for molding and chipboard volume.

Difficulties in managing structural interdependencies and the need for parametric assumptions and estimated elasticities make the usage of parametric models harder. In addition to the difficulties of applying parametric models, easier use of machine learning tools and increased accessibility of data sources are supportive reasons to use non-parametric models. There are some studies compare parametric and non-parametric models in trade forecasting. For example, Co & Boosarawongse (2007) compared Artificial Neural Network (ANN) model with parametric models for the forecasts of Thailand's rice export. Their study applied to four different types of rice products. To compare the models, exponential smoothing and ARIMA techniques were taken as parametric models and ANN was taken as the non-parametric model. They showed that ANN yielded the best forecast results. In a similar study, Pakravan, Kelashemi, & Alipour (2011) studied the forecasting of Iran's rice import by using ANN. Singular Spectrum Analysis is used by Silva & Hassani (2015) to forecast the trade of the United States before, during and after the recession of 2008. To analyze and forecast global bilateral trade flows of sawn wood, Nummelin & Hänninen (2016) studied various machine learning models. Support vector machines (SVM), random forests, ANN and their variations were used in their study. Similar to our model, the model build by Nummelin & Hänninen (2016) uses not only export volumes but also other economic indicators, such as exchange rates and Gross Domestic Product (GDP), however, their model includes a very limited number of factors. Shibasaki & Watanabe (2012) forecasted cargo flow in Asia-Pacific Economic Cooperation (APEC) region by using relations between economic growth, trade, and logistics demand models. Sokolov-Mladenović et al. (2016) forecasted economic growth by using ANN which is based on trade, import, and export parameters. Using the same relationship, our model takes economic growth as an input to forecast international trade but uses more input factors. Gupta & Kashyap (2015) used ANN to forecast inflation in G-7 countries where our model takes inflation as one of the input factors to predict import and export volumes.

MAIN FOCUS OF THE CHAPTER

The first research question that we address in this study is "How can we use open data sources in bilateral trade forecasting?". The next question is "Which factors are affecting the bilateral trade forecasting?". The third one is "How can we achieve accurate forecast results in the selected machine learning method?". These are the main research questions we address in this study. To answer these questions, we used our proposed forecasting methodology to forecast trade volumes. However, the product and the country pair (exporting and importing) should be selected first to conduct the analyses.

In international bilateral trade, there are three important aspects for evaluating current and future business situations. The first point is the representation of the market. A single country, geographical region (West Africa, Far East, etc.) or a group of countries with a common point of agreement (EU, OECD, etc.) can be considered as the market. The next aspect is the level of detail of the product definition. The third one is the forecast horizon, which may vary from a month to years. Product level of detail is handled according to Harmonized Commodity Description and Coding System (HS)[1] levels. HS is an international coding system for the classification of products. The products are represented as six-digit codes in HS. The first two digits of an HS code represents the main chapter of goods (e.g., "84" is "Machinery"). The next two digits represent the grouping within that chapter. For example, "84.18" code "Refrigerator and freezers" group in machinery chapter. The last two digits identify a specific product in that group. For example, "84.18.10" represents "Refrigerators and freezers fitted with separate external doors".

For our study, Chapter 84 (Machinery) is selected because it is closely related to the end-customer behavior. Also, according to Turkey's export volumes (see Table 1), Chapter 84 (Machinery) is the second biggest export chapter to the World after Chapter 87 (Vehicles). Within Chapter 84, the product group of refrigerators and freezers (HS=84.18) is the biggest product group according to the export volumes. To be more product specific, three different product types are selected in HS=84.18 group. According to trade volumes in 2016, these three product types are top three exported products from Turkey in that product group. The three product groups selected in our study are listed below:

- **84.18.10:** Refrigerators and freezers; combined refrigerator-freezers, fitted with separate external doors, electric or other
- **84.18.40:** Freezers; of the upright type, not exceeding 900l capacity
- **84.18.50:** Furniture incorporating refrigerating or freezing equipment; for storage and display

As seen in Table 2, United Kingdom is the biggest importer in HS=84.18 product group from Turkey in 2016. Due to these reasons, for our Bilateral Trade Forecasting case presented in this chapter, Turkey and United Kingdom are selected as the source (exporting) and target (importing) countries, respectively.

METHODOLOGY

Big Data Analytics can be seen as data manufacturing and it is similar to traditional manufacturing (Hazen et al., 2014) because raw data are converted into forecasted

Table 1. Turkey's export volumes according to HS Codes (Thousand USD)

HS Code			Product Label	2015	2016	2017	2018
87			Vehicles other than railway or tramway rolling stock, and parts and accessories thereof	17,463,564	19,801,974	23,940,852	26,759,684
84			Machinery, mechanical appliances, nuclear reactors, boilers; parts thereof	12,333,803	12,339,237	13,825,494	15,831,703
	8418		Refrigerators, freezers and other refrigerating or freezing equipment, electric or other; heat . . .	1,721,260	1,740,073	1,802,257	1,970,693
		841810	Refrigerators and freezers; combined refrigerator-freezers, fitted with separate external doors, electric or other	711,584	884,550	916,703	992,722
		841850	Furniture incorporating refrigerating or freezing equipment; for storage and display	231,983	241,678	259,520	295,578
		841840	Freezers; of the upright type, not exceeding 900l capacity	184,068	197,103	202,870	220,714

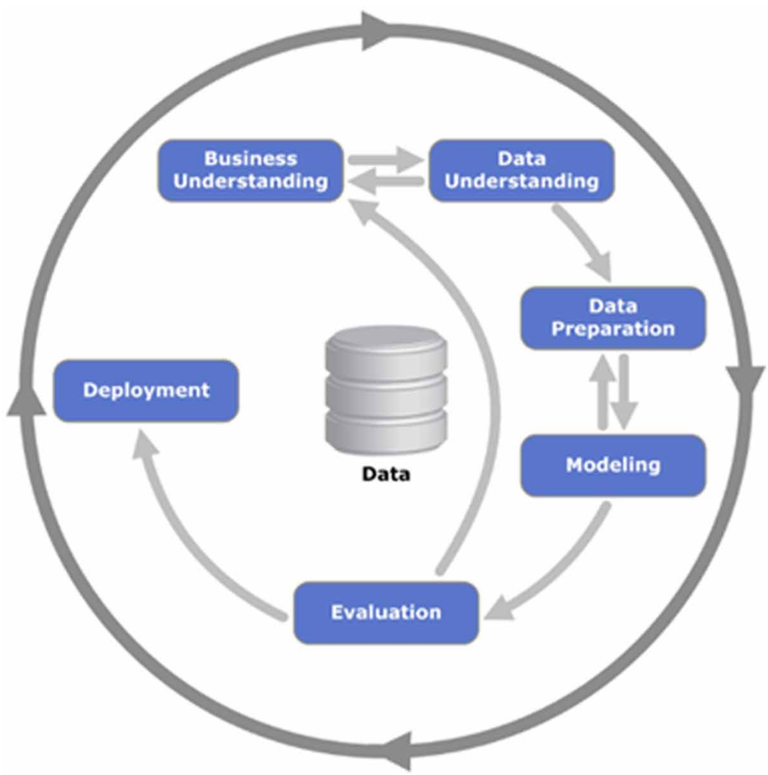
Table 2. Turkey's export partners in HS 84.18 product group (Thousand USD)

Country	2015	2016	2017	2018
United Kingdom	222,308	212,341	200,071	224,844
Germany	188,426	202,314	211,439	220,487
United States of America	101,850	108,716	128,181	171,648
France	131,387	118,826	105,107	124,153
Italy	81,251	98,137	121,638	106,398

data like converting raw materials into physical products. Our study is based on CRISP-DM (CRoss Industry Standard Process for Data Mining) which was used by Wirth & Hipp (2000). To forecast trade volumes between countries, we used all the steps of CRISP-DM (business understanding, data understanding, data preparation, modeling and evaluation). In Figure 1, the followed CRISP-DM process is given.

As the first step, business understanding is crucial. In this step, the dynamics and potentially influential factors for bilateral trade are identified. After doing a literature survey and conducting appropriate research, the candidate factors are identified. These factors come from various domains, such as trade, economy, business and politics. Since our aim is to forecast the bilateral trade volume, there are some constraints for determining factors. In this study, we included more than 10 years of data, to have enough training and test sets. The data set is examined according to intrinsic data dimensions (Wigan & Clarke, 2013). Intrinsic dimensions are accuracy, timeliness, consistency, completeness and frequency. The first concern is

Figure 1. CRISP-DM (CRoss Industry Standard Process for Data Mining) process



the accuracy and our 10 years of data are reachable from reliable open data sources. The next one is timeliness, and the start and end dates of our data are around 2007 and 2017, respectively. Completeness is the next dimension, and it means that data do not have any missing points during that period. Consistency dimension is the expectancy to be on the same unit or at least convertible to the same unit. As the frequency dimension, the monthly period is selected in our model and data served in monthly periods are preferred. After passing all these intrinsic data dimension constraints, the features used in the forecast models are determined.

The features are the factors affecting the trade volume and summarized in Table 3. These factors can be grouped into two main groups: (1) product-specific trade information, and (2) country or global conditions related features. The components affecting bilateral trade are mainly supply and demand factors of the related countries (Ayankoya, Calitz, & Greyling, 2016; Kangas & Baudin, 2003; Nummelin & Hänninen, 2016). To model the demand for a specific product in a target country (in our study, United Kingdom), the trade volumes of the top five exporters to the target country are considered. To model the supply from the source country (in our study, Turkey), the trade volumes of the top five target countries that the source country exports are taken into account. As the last product specific factor, the unit value of the traded product is included in the model. Country or global factors are product independent data. These factors are divided into the political environment, business environment (Bovi & Cerqueti, 2016), economic environment (Keck, Raubold, & Truppia, 2010; Sokolov-Mladenović et al., 2016) and trade environment-related factors. Business environment is represented by adding Business Confidence and Consumer Confidence Indicators. With the inclusion of Economic Political Uncertainty Index, political factors are covered. Economic factors are GDP, Exchange Rates, Composite leading Indicators, Consumer and Producer Price Indices. World Trade Volume and World Economic Political Uncertainty indices are included as global trade parameters. To obtain these data, four different open data sources are used (see Source column of Table 3).

According to CRISP-DM methodology, the next step is data understanding. There are two different trade data reporting the trade volumes. These are export data reported by exporter country and import data reported by the importer country. These two data do not fully match with each other due to the differences in export and import data keeping procedures of the countries. In this study, to be consistent, the trade data based on data reported by the exporter countries are used.

After data understanding step, data preparation step is applied. In this step, data sets from different sources are formatted to be on the same basis and joined according to their dates. In addition, multiple entries are cleaned. Time windowing

Table 3. The features used in the proposed big data analytics trade forecasting model

Group	Feature	Source
Trade Information	• Supply Capacity of the Source Country for each Product: Export volume of top five importing countries from Turkey (the countries for each product are given in Table 5) • Total Supply Capacity of the Source Country for each Product: Turkey's export volume to the World • Demand Capacity of the Target Country for each Product: Import Volume of top five exporting countries to United Kingdom Turkey (countries for each product are given in Table 5)	International Trade Center
	• Unit Value of each Product from Source Country (Turkey) to Target Country (United Kingdom)	
Political Environment	• Economic Policy Uncertainties of Source and Target Countries, and the World: EPU [a]	Economic Politic Uncertainity
Business Environment	• Business Confidence Indicators of Source and Target Countries: BCI • Consumer Confidence Indicators of Source and Target Countries: CCI	OECD
Economic Environment	• Composite Leading Indicators of Source and Target Countries: CLI	OECD
	• GDPs of Source and Target Countries: GDP	
	• Producer Price Indices of Source and Target Countries: PPI	
	• Consumer Price Indices of Source and Target Countries: CPI	
	• Exchange Rate of Local Currencies of Source and Target Countries to USD: TRY and GBP	
Trade Environment	• Total World Trade Volume	CPB World Trade Monitor

[a] EPU of Turkey is not included in the study, since there is no available data for Turkey

is done by shifting the data points one through eight months. After time windowing, the dependent variable data sets and independent variable data sets are prepared for each product to determine the forecast horizon. All data combinations are created to find the best set of dependent variables from past trade data. These combinations are based on monthly data as listed in Table 4. For example, 2 months ahead forecast horizon of two input month combinations uses the data of two and three months ago.

In the modeling step, common machine learning methods can be applied. Random Forests, Artificial Neural Networks, Decision Trees, Support Vector Machines, or Association Rule Analysis are some of the algorithms in order to derive knowledge from data reflecting conditions, processes and patterns (Stahlbock & Voß, 2010). Our data set contains monthly input data and can be classified as a multivariate time series. Because of their learning ability from complex relationships from these multivariate data (Mishra, Mishra, & Santra, 2016), Random Forests and Artificial Neural Networks are selected as forecasting methods herein.

Table 4. Forecast horizon and input month combinations

Input month combinations	Forecast Horizon					
	1 month ahead	2 months ahead	3 months ahead	4 months ahead	5 months ahead	6 months ahead
Single	Only -1	Only -2	Only -3	Only -4	Only -5	Only -6
Two	-1 and -2	-2 and -3	-3 and -4	-4 and -5	-5 and -6	-6 and -7
Three	-1, -2 and -3	-2, -3 and -4	-3, -4 and -5	-4, -5 and -6	-5, -6 and -7	-6, -7 and -8

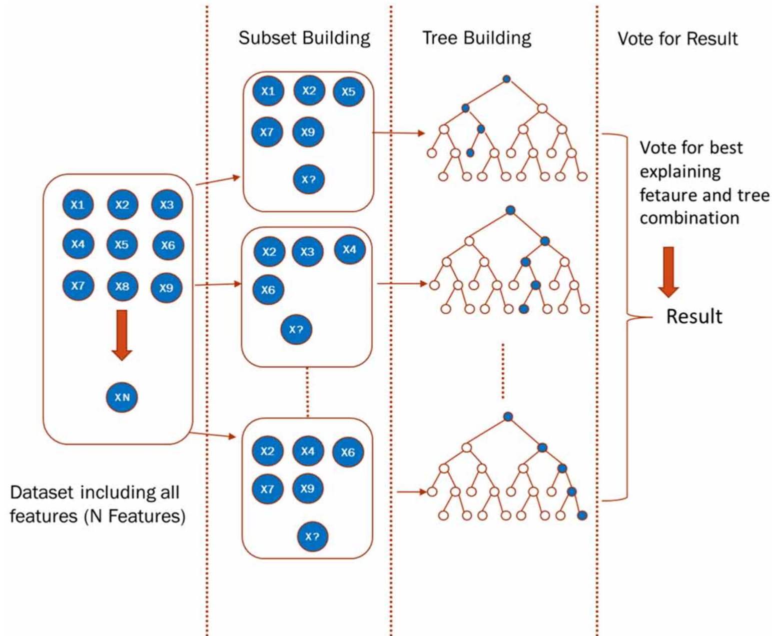
Random Forest (RF)

Decision Tree is a widely used machine learning method for both classification and regression. Random Forest Model is based on ensemble learning by different Decision Trees. This ensemble learning approach was first developed by Breiman (2001). A prediction by using a single decision tree mainly depends on the formation of the training set. It can cause overfitting problem in the train set and low-quality results in the test set. To avoid this overfitting due to the single dimension of randomness in a single decision tree, random forest algorithm trains each tree with a random subset of the complete data set. Including the second dimension of randomness by using random subsets, Random Forest algorithm has the ability to reach high stability and robustness. This property allows using the best features among a random subset of candidate features. Therefore, Random Forest is used not only in forecasting but also in the feature selection processes. In Random Forest method, after creating a large number of trees, the best descriptive combination is selected within that trees (Breiman, 2001). Figure 2 summarizes this procedure used in Random Forest algorithms.

Artificial Neural Networks (ANN)

For the last two decades, Artificial Neural Networks have been used in various application areas (Tkáč & Verner, 2016). The ANN's first application is dated back to 1964 with a weather forecast model (Zhang, Patuwo, & Hu, 1998). Since neural networks have become a mature technique, it has a wide range of applications including forecasting, credit scoring, financial analysis, customer metrics to fraud analysis (Chen & Zhang, 2014; Tkáč & Verner, 2016). In the ANN, there are computational structures that are designed to mimic biological central nervous system (Nummelin & Hänninen, 2016; Zhang et al., 1998). ANN is based on the idea of accumulation of knowledge during training sessions. Due to the generalization ability coming from the knowledge accumulation attribute, the ANN can be used in any function

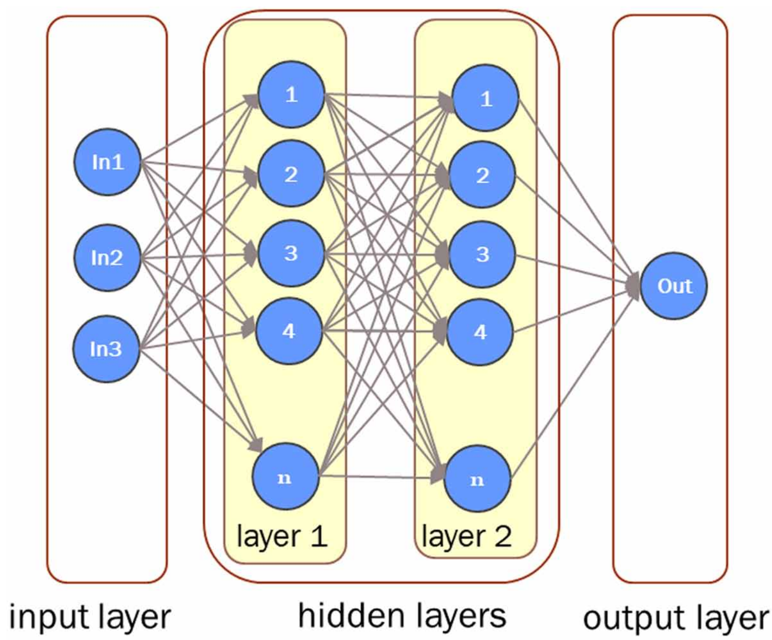
Figure 2. The procedure of random forest algorithm



approximation problem (Iebeling & Milton, 1996). The important benefits of the ANN, such as the efficiency, robustness and adaptability, make it a valuable tool for pattern recognition, classification and forecasting. There are various types of Neural Network topologies. Multi-layer Perceptron (MLP), Recurrent Neural Networks (RNN), Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) are some of the well-known ANN topologies (Øyen, 2018). In this study, MLP with the feedforward type selected, because it is one of the most widely used topologies in forecasting and it has low resource requirements. MLP topology consists of three layers: the input layer, hidden layer and output layer. The task of the input layer is to transfer raw input data to the network. The number of nodes in the input layer depends on the number of features used in the model. The next element in the network is the hidden layer, which consists of multiple layers and many nodes within them. After the hidden layer, the output layer is located. The final solution is produced in the output layer. Figure 3 shows a Multi-Layer Perceptron topology with three inputs, hidden layers (with two layers) and a single output. Note that each node in MLP is fed from the nodes of the previous layers and they are fully connected.

Each node has four components: input, weight, bias, and activation functions. The input of each node is generated by the outputs of the previous layer nodes. Weight is

Figure 3. A Multi-Layer Perceptron topology with three inputs, two hidden layers and a single output

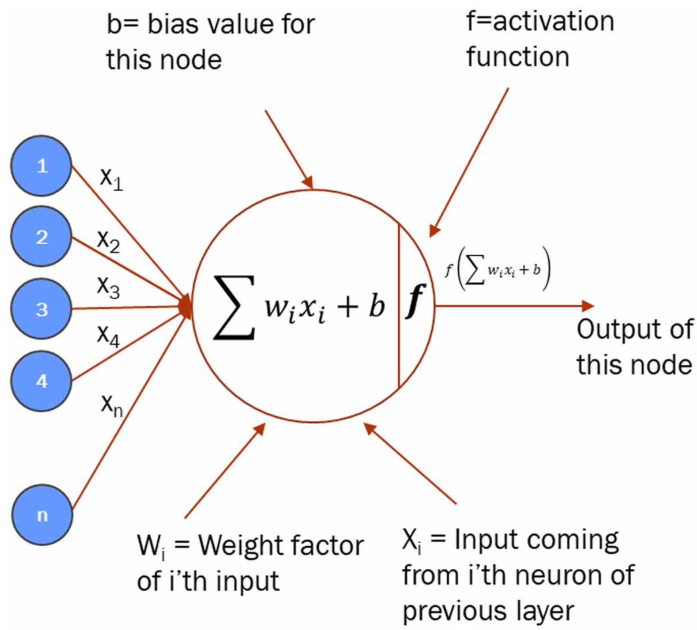


the transformation factor of each input. Bias is a general factor in each node. A linear transformation applied to input values using weight and bias as shown in Figure 4. The summation passes through an activation function, which decides how much of the information from this sum is the resulting output for that node. Non-linearity of ANN is provided by this activation function, which can be can be various types, such as logistics sigmoid or hyperbolic tangent (Øyen, 2018).

While training the MLP, the calculations are bi-directional. In the first move, the train data set passes through the entire network and results in an output. This move is called the forward directional calculation move. This output is the network's prediction results. Prediction results of train set and real values of train set are compared to find necessary adjustments. After calculation the difference between the predicted and real values, backpropagation step starts in the reverse direction. In this backward move, various types of solver methods are used to optimize weights and biases in each node. The solvers continue to optimize weights with these back and forth moves until the convergence achieved or a certain number of iterations is reached.

All machine-learning methods use two types of parameters. Some of them are determined before the training process and some of them are calculated during

Figure 4. Mathematical model for a single node



the training process. Parameters set before the training process are called as hyperparameters. Each model has a different hyperparameter sets. For Random Forest, maximum features, minimum samples leaf, and maximum leaf nodes are some of the hyperparameters. The hyperparameters of Random Forest are explained in the next section (see Table 9). Solver type, activation function type and the maximum number of iterations are some hyperparameters of MLP. These hyperparameters are explained in the next section (see Table 11) in detail. To achieve more robust and successful results, convenient hyperparameter values should be found by applying a tuning process instead of using the default parameter values of the algorithms. In the tuning process, high R^2 scores and robustness are aimed. The evaluation of the results is the final step of CRISP-DM and is presented in the following section including the detailed preliminary analysis on data preparation and the process of hyperparameter tuning.

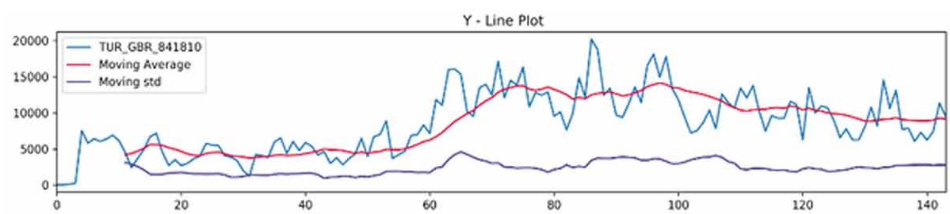
SOLUTIONS AND RECOMMENDATIONS

As explained in Main Focus Section in detail, our model is built to forecast the trade volumes of three types of products from Turkey to United Kingdom. The data set used in the forecasting model is combined from different open data sources that are given in the "Source" column of Table 3. The resulting data set is from 2006 April to 2018 March with 144 monthly data points. To give an insight about data series, time series plot with moving average and moving standard deviation values for products 841810, 841840 and 841850 are given in Figure 5, Figure 6 and Figure 7, respectively.

The top five importers and exporters are determined based on Turkey's yearly exports and United Kingdom's total import volumes in 2016. The list of importer and exporter countries given in Table 5.

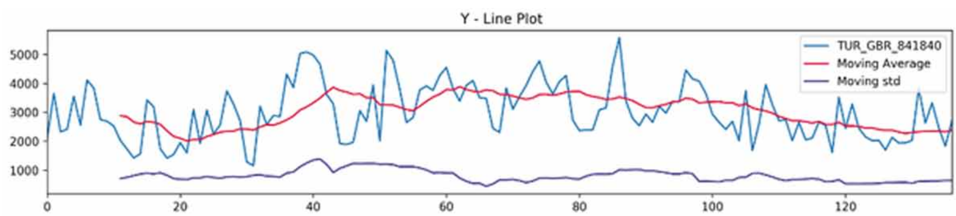
The main process of our proposed Big Data Analytics methodology is presented in Figure 8. For all products, there are 28 features in both random forest and neural network models. The specific features to be used in the model depend on the

Figure 5. Time series plot for export product 841810 from Turkey to United Kingdom



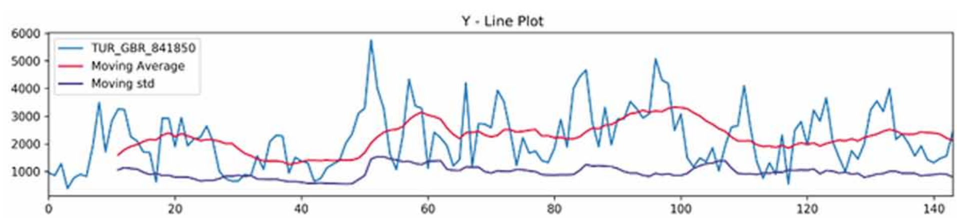
**For a more accurate representation see the electronic version.*

Figure 6. Time series plot for export product 841840 from Turkey to United Kingdom



**For a more accurate representation see the electronic version.*

Figure 7. Time series plot for export product 841850 from Turkey to United Kingdom



**For a more accurate representation see the electronic version.*

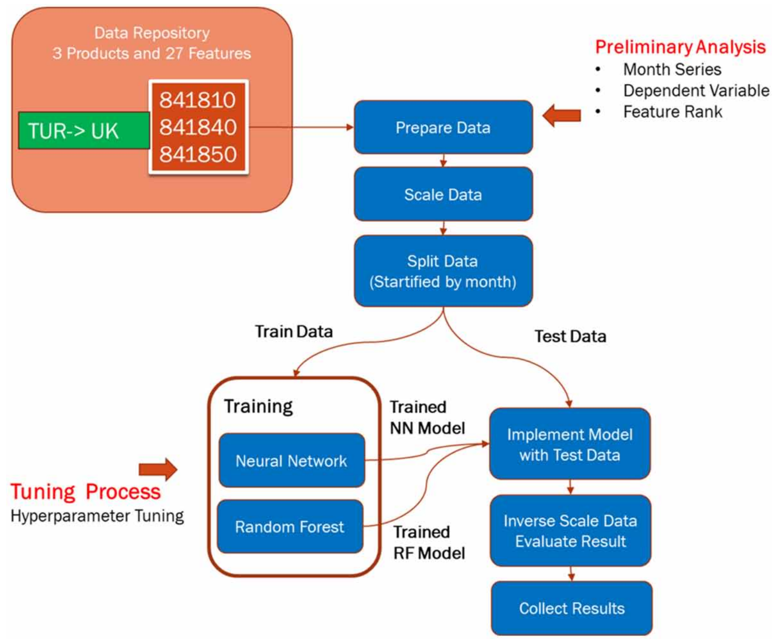
Table 5. The top five importers from Turkey and exporters to United Kingdom for each product in 2016

Product HS Code	The top five ımporting countries from Turkey (Sorted by the largest trade volume to the lowest)	The top five exporting countries to United Kingdom (Sorted by the largest trade volume to the lowest)
841810	Germany, United Kingdom, Italy, France, United States	China, Turkey, Poland, Korea, Republic of, Italy
841840	United Kingdom, United States, France, Germany, Sweden	Turkey, China, Germany, Hungary Netherlands
841850	United Kingdom, Germany, Iraq, Saudi Arabia, Netherlands	Italy, China, Turkey, Austria, Czech Republic

preliminary study. This preliminary step analyzes the effects of the input month combinations, feature selection and dependent variable transformation decisions on the forecast quality. Without preliminary analysis model, the model forecasts one month ahead using the previous month's data and all other features without transforming the dependent variable. As the first step, the data of each feature is scaled according to min-max normalization since each feature in our data set has different ranges. After the scaling step, the data split into training and test sets. The training set is 80 percent of the entire data set with 115 observations and test set is the remaining 20 percent with 28 observations. Data stratification is applied to ensure the presence of each month to be included train and test sets. Therefore, the accumulation of certain months in test or training sets is prevented. Training is held by using train data. If no tuning process is applied to the models, then both model takes default values for hyperparameters. The hyperparameters of Random Forest and Artificial Neural Networks are specific to the method and affect the quality of the results. Trained models are tested with the test data to see the performance of the model. Since all data are scaled (including dependent variable) inverse scaling should be applied to see the real behavior of the output. Both models were implemented by using "scikit-learn" open source libraries for Python on a Windows PC. Python libraries of "MLPRegressor" and "RandomForestRegressor" were used for Neural Network and Random Forest implementations, respectively.

During the data preparation, a preliminary search process is conducted with three aspects to achieve successful results on forecasting. After checking these three aspects, the tuning process is started. The first aspect is to decide on which month or month combinations of the past trade data should be taken as input factors in the forecasting model. The month combinations are given in the first column of Table 6. Note that, Table 6 only reports the summary of the important results since extensive analyses were conducted with different combinations. The second aspect

Figure 8. The proposed big data analytics process followed in this study



is the feature selection threshold, which defines the percentage of the features to be included in the model according to their feature selection scores. The searched options are 50 percent, 75 percent, and 100 percent. In this case, 50 percent means that only half of the features are included in the model according to their feature ranks and the remaining ones are omitted. To calculate each feature's rank two methods are combined. The third aspect is to determine the usage of the dependent variable. In this aspect, three options are searched: (1) same (no transformation), (2) transformed with logarithm and (3) transformed with square root. With all these aspects and their combinations, 162 different data sets are trained. The results of this preliminary search with 162 combinations (with 10 random seed each) are presented in Table 6. According to these results, the dependent variable without any transformation, with 50 percent of the most important features and with the past trade data of 6 and 7 months yield the best result (R^2 of 0.859) for product 841810.

Repeating this process for the other products gives the best combinations for all products as shown in Table 7. The results indicate that the products 841840 and 841850 have the best forecast horizon of four months, while the product 841810 has the best forecast horizon of six months. For all products, the feature selection with 50 percent of the most important features achieved the best results. According to the results, two months of past data for products 841810 and 841850, while single

Table 6. The R^2 results of the preliminary analysis for product 841810

Dependent Variable		same			sqrt			log		
Selected Features		**50**	**75**	**100**	**50**	**75**	**100**	**50**	**75**	**100**
Past Trade Data (Months)	-1	0.789	0.780	0.775	0.765	0.757	0.752	0.735	0.738	0.741
	-1 and -2	0.780	0.767	0.775	0.767	0.754	0.751	0.745	0.742	0.740
	-1, -2 and -3	0.773	0.770	0.767	0.776	0.762	0.761	0.767	0.760	0.754
	-2	0.772	0.765	0.768	0.759	0.756	0.753	0.739	0.743	0.738
	-2 and -3	0.759	0.764	0.768	0.771	0.773	0.770	0.776	0.763	0.761
	-2, -3 and -4	0.773	0.774	0.773	0.780	0.774	0.777	0.772	0.767	0.768
	-3	0.757	0.777	0.765	0.793	0.786	0.783	0.787	0.777	0.772
	-3 and -4	0.783	0.780	0.776	0.786	0.789	0.787	0.788	0.786	0.780
	-3, -4 and -5	0.817	0.810	0.803	0.811	0.800	0.803	0.793	0.786	0.782
	-4	0.781	0.789	0.789	0.772	0.788	0.786	0.767	0.763	0.771
	-4 and -5	0.826	0.813	0.813	0.796	0.804	0.797	0.775	0.770	0.775
	-4, -5 and -6	0.830	0.821	0.816	0.830	0.817	0.818	0.805	0.802	0.801
	-5	0.827	0.816	0.815	0.782	0.802	0.793	0.766	0.757	0.765
	-5 and -6	0.828	0.819	0.817	0.831	0.824	0.822	0.811	0.800	0.801
	-5, -6 and -7	0.858	0.852	0.845	0.847	0.839	0.839	0.811	0.812	0.818
	-6	0.814	0.814	0.806	0.829	0.826	0.819	0.788	0.805	0.803
	-6 and -7	0.859	0.843	0.835	0.841	0.833	0.835	0.806	0.810	0.807
	-6, -7 and -8	0.823	0.816	0.810	0.831	0.814	0.807	0.792	0.785	0.783

Table 7. Preliminary analysis results to determine best input combination for each product

Product HS Code	Past Trade Data (Months)	Transformation of the Dependent Variable (same, log, sqrt)	Percentage of Selected Feature (50%, 75%, 100%)
841810	-6 and -7	same	50
841840	-4	same	50
841850	-4 and -5	same	50

month past data for product 841840 are used in the model. For all products, using the dependent variable as it is (without transformation) yielded the best results.

After this preliminary search, the top 10 features used in forecasting models are listed in Table 8 where the data labels are standardized for easy understanding. For example, TUR_GBR_841810-3 stands for: Source country is Turkey, Target Country

Table 8. The top ten feature list for each product

Rankings of the features	Product HS Code		
	841810	841840	841850
1.	CCI_TUR-6 [a]	TUR_FRA_841840-4	TUR_World_841850-4
2.	CPI_TUR-7	CCI_GBR-4	TUR_IRQ_841850-4
3.	CCI_TUR-7	GDP_GBR-4	CCI_TUR-4
4.	CPI_GBR-6	NLD_GBR_841840-4	CLI_TUR-4
5.	CPI_TUR-6	TUR_DEU_841840-4	World-4
6.	CPI_GBR-7	HUN_GBR_841840-4	BCI_TUR-4
7.	TUR_FRA_841810-6	EPU_World-4	BCI_GBR-4
8.	TUR_ITA_841810-6	TRY-4	ITA_GBR_841850-5
9.	TUR_DEU_841810-6	GBP-4	CCI_TUR-5
10.	POL_GBR_841810-7	TUR_GBR_841840_UV-4	CHZ_GBR_841850-4

[a]CCI refers to Consumer Confidence index, TUR indicates Turkey, and -6 means six months ago. The other variables in this table are coded similarly.

is the United Kingdom, the product is 84.18.10 and the export values are shifted three months back. For all product types, Consumer Confidence Indicator plays an important role. Supply Capacity of the Source Country and Demand Capacity of the Target Country are common for all products. Consumer Price Index is a dominant feature for product 841810 whereas it does not appear in the other products. Note that the other features are product type dependent, which demonstrates the importance of our preliminary analysis.

Then, the hyperparameters are tuned for both Random Forest and Artificial Neural Networks algorithms according to the process is summarized in Figure 9.

The hyperparameters of the Random Forest algorithm are explained in Table 9. Upon completing the tuning process for each product, hyperparameter values were obtained as in Table 10. Only one parameter value is common for all products, therefore applying the tuning process and using the appropriate parameters are very important to achieve good quality results.

The hyperparameters of the Artificial Neural Network algorithm are explained in Table 11. Similar to the tuning process of the Random Forest model, the hyperparameter values of the Artificial Neural Network models for each product are fixed as in Table 12. Only two parameter values, “solver” and “activation”, are common for all products. Again, this shows the importance of the tuning process.

To demonstrate the efficiency of the tuning process, Figure 10 compares the R^2 values of the Random Forest model between tuned hyperparameter values and default (not tuned) hyperparameter values for all products. The cases of tuned and

Figure 9. Tuning process for random forest and artificial neural network algorithms

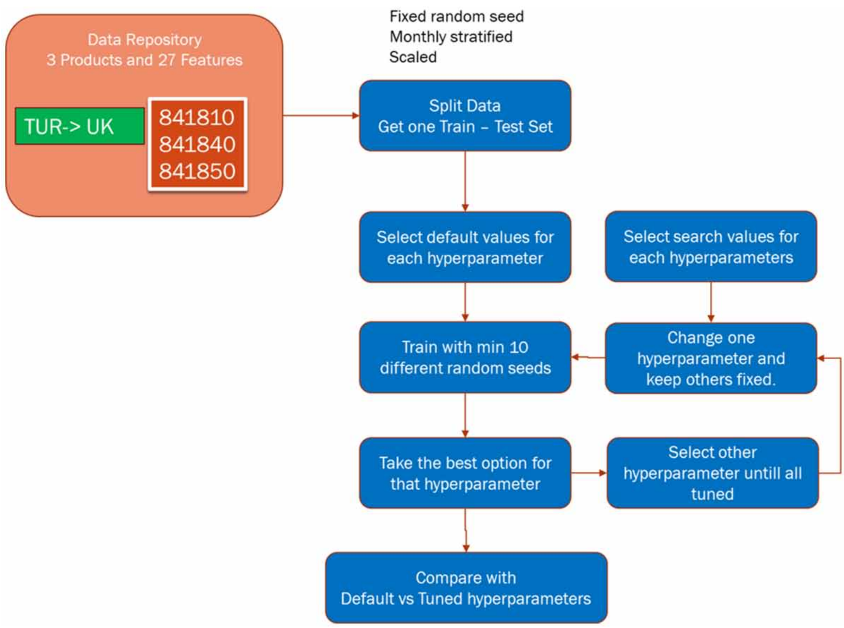


Table 9. The hyperparameters of the random forest model

Hyperparameter	Description
Maximum Features	It refers to the number of variables randomly sampled as candidates at each individual decision tree. Four different parameters (10,"log2","sqrt" and "auto"). The default value is 10.
Minimum Sample Leaf	It represents the minimum number of samples in newly created leaves. Five different parameters (which 1, 2, 5, 20 and 30) are selected in tuning. The default minimum sample leaf is 5.
Maximum Leaf Nodes	It refers to the maximum number of terminal node trees that a forest can have. Five different parameters (2, 5, 10, 100, 200 and 300) are selected in tuning. The default maximum leaf node is 100.
Minimum Weight Fraction For Leaf	It stands for the threshold value for minimum weighted fraction of the sum total of all input weights in newly created leaves. Five different parameters (0.00001, 0.0001, 0.001, 0.01 and 0.1) are selected in tuning. The default minimum weight fraction for leaf is 0.00001.
Minimum Impurity Decrease	It refers to the threshold value for the impurity decrease achieved by node split. Three different parameters (0.000001, 0.00001, 0.001 and 0.01) are selected in tuning. The default impurity decrease is 0.001.
Number Of Estimators	It represents the number of trees created in the forest by the algorithm. Seven different parameters (100, 200, 500, 1000, 5000, 10000 and 20000) are selected in tuning. The default estimator is 200.
Random State	It is the random number used while training. Since each training session is held with different random seed, random state is excluded from tuned hyperparameter set.

Table 10. Tuned values for hyperparameters of the random forest model for all products

Product HS Code	Maximum Features	Minimum Sample Leaf	Maximum Leaf Nodes	Minimum Weight Fraction For Leaf	Minimum Impurity Decrease	Number Of Estimators
841810	auto	1	300	0,0001	0,000001	1000
841840	10	5	100	0,0001	0,000001	5000
841850	10	2	10	0,00001	0,001	1000

Table 11. The hyperparameters of the neural network model

Hyperparameter name	Description
Solver	It is the solver method used for weight optimization in network. There are three options (“lbfgs”, “sgd” and “adam”) in library for this parameter which. The default solver is “adam”.
Activation	It refers to the activation function type used in layers. There are four options (“identity”, “logistic”, “tanh” and “relu”) in the library and the default activation function is “relu”.
Alpha	It denotes the regularization parameter by giving penalty to the system. Three different parameters (0.001, 0.00001 and 0.0000001) are selected in tuning. The default alpha is 0.001.
Maximum Number Of Iterations	It refers to the solver continue to optimize weights until to reach this number of iterations. Four different parameters (1000, 10000, 50000 and 100000) are selected in tuning. The default maximum iteration is 200.
Hidden Layer Size	It represents the topology of the network in hidden layer. It has two dimensions, the number of layers and the number of neurons on each layer. The default is (30, 30) and it means two hidden layers with 30 neurons each. 5 different hidden layer size option is determined for tuning which, (10, 10), (30, 30), (100, 100), (30, 30, 30) and (30, 100, 30).
Learning Rate	It changes the weight optimization learning rate strategy. There are three options in library for this parameter which are ‘constant’, ‘invscaling’ and ‘adaptive’. This parameter works only where the solver is ‘sgd’. Since our set has small number of observations, ‘lbfgs’ perform better than the other solvers. Therefore, this hyperparameter omitted from tuning process.
Random State	It denotes the random number used during training. Since each training session is held with different random seed, random state is excluded from tuned hyperparameter set.

default values are repeated with 10 different random number seeds for each product. As seen from Figure 10, the tuning process yielded significantly higher R^2 values and more robust results in the Random Forest model. The same results are observed in the Artificial Neural Network model as well. Therefore, the tuning process is an essential step to increase forecast accuracy.

Table 12. Tuned values for hyperparameters of the neural network model for all products

Product HS Code	Solver	Activation	Alpha	Maximum Number Of Iterations	Hidden Layer Size
841810	lbfgs	identity	0,0000001	100000	(30, 30, 30)
841840	lbfgs	identity	0,0000001	10000	(10, 10)
841850	lbfgs	identity	0,00001	10000	(30, 30)

For all products, Random Forest and Artificial Neural Network algorithms were compared according to R^2 values. As shown in Figure 11, Random Forest gives better R^2 values than Neural Network models for all product types. Note that, Figure 11 presents the median R^2 values with the tuned hyperparameters for both algorithms.

Figure 10. Before tuning and after tuning R^2 results of the Random Forest for all products

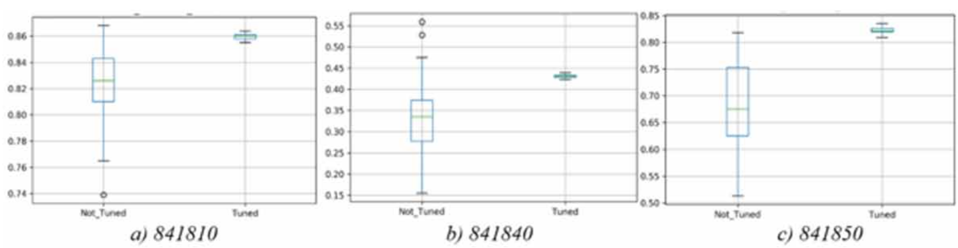
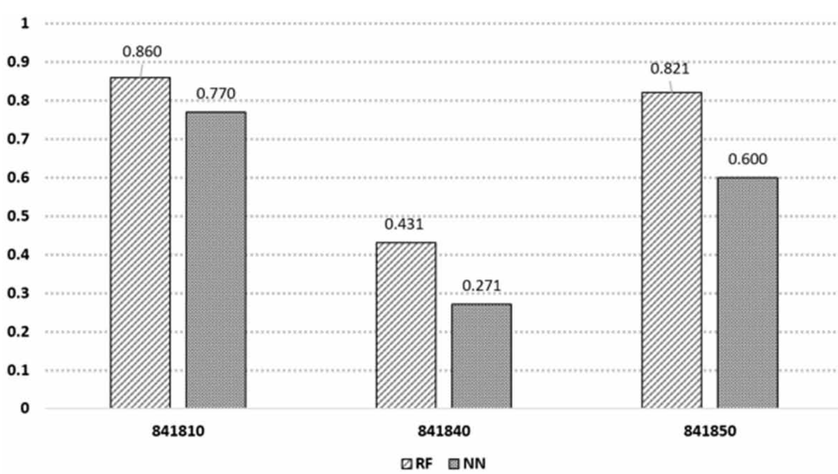


Figure 11. The median R^2 values of random forest and artificial neural network models for all products



Among three product types, Product 841810 gives the best result with 0.86 R^2 value and 841840 gives the lowest R^2 value.

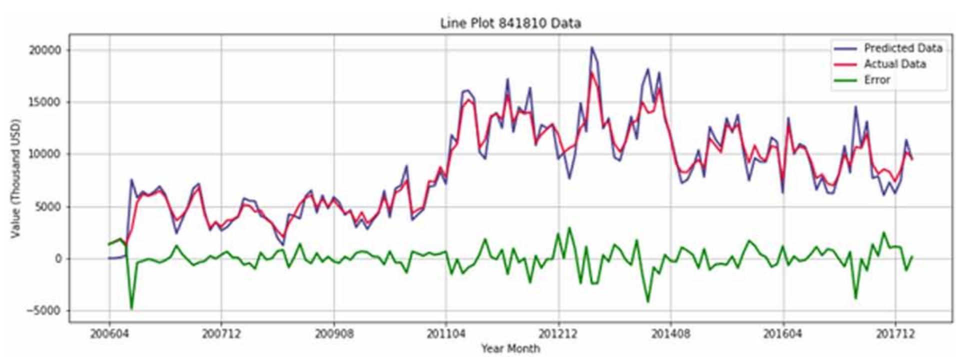
The scatter plots presented in Figure 12 show the actual and predicted values of train and test data in the Random Forest model. In this figure, the blue dots represent the train data and the red ones represent the test data. Note that, R^2 values given in Figure 11 are calculated for the test data. Figure 13, Figure 14 and Figure 15 show the forecasts of all products with the Random Forest model.

During the tuning and training processes, the main goal is to increase the R^2 value of the test set. However, R^2 value for the train set can decrease while increasing R^2 value for the test set. For example, Table 13 shows the R^2 value changes in the Random Forest model with the tuning and training processes for 841810 product because this product type has the most dramatic results. According to these results,

Figure 12. Scatter plots for the train and test data prediction of the random forest model for all products

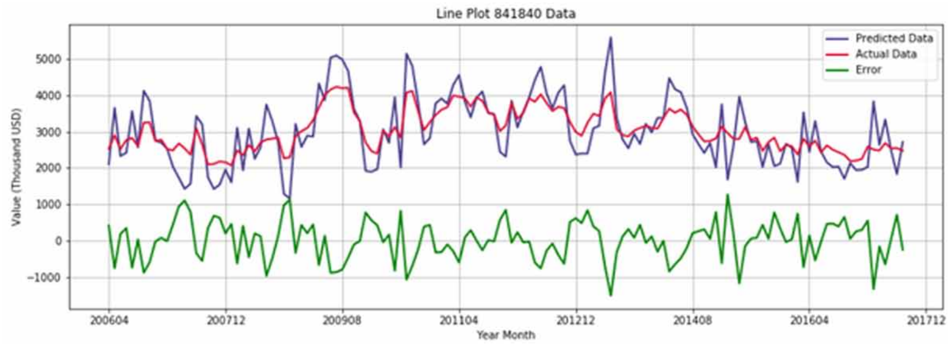
a) 841810 *b) 841840* *c) 841850*

Figure 13. Line plot of all data set for product 841810 from Turkey to United Kingdom



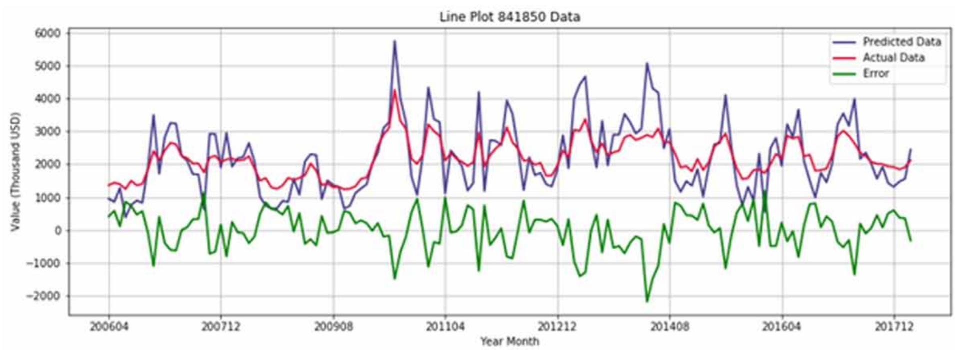
**For a more accurate representation see the electronic version.*

Figure 14. Line plot of all data set for product 841840 from Turkey to United Kingdom



**For a more accurate representation see the electronic version.*

Figure 15. Line plot of all data set for product 841850 from Turkey to United Kingdom



**For a more accurate representation see the electronic version.*

although the train set achieves high R^2 value, the test set has significantly lower R^2 value. This indicates a possible overfitting problem of the train set. Also, the default hyperparameter values yield higher R^2 values than the tuned parameters for the train set, however, higher test R^2 values are achieved by the tuned hyperparameters. Therefore, lower R^2 values in the train set do not necessarily indicate lower R^2 values

Table 13. R^2 value changes in the Random Forest model with the tuning and training processes for 841810 product

	R^2 for Test Set	R^2 for Train Set	R^2 for All Data Set
Trained with default hyperparameters	0.42	0.958	0.87
Trained with tuned hyperparameters	0.446	0.807	0.752

in the test set. Similar results were observed with the other products, however, their R^2 values are significantly higher and overfitting does not seem to be a problem. In addition, overfitting is not a significant issue for 841810 product because it has acceptable R^2 values (0.446). The same tests were conducted with the Artificial Neural Network model and the same observations were made.

CONCLUSION AND FUTURE RESEARCH DIRECTIONS

Today's supply chain operations have become more complex due to globalization. Therefore, many supply chain operations, such as production, procurement, sales, warehousing, and forecasting, should be designed with considering global factors. Among these factors, international trade significantly affects the performance of the global supply chain operations. Forecasting the future trade volumes of specific products between countries can help companies to adapt to new trade environments and make their supply chain decisions accordingly. However, with the increased complexity of the global supply chain networks and global trade between countries, forecasting has become harder. Using Big Data Analytics, accurate forecasts can be achieved.

In this chapter, we presented a new Big Data Analytics methodology to forecast trade volumes of specific products between the two countries. In this methodology, various open data sources are used to forecast trade volumes. As the main forecasting algorithm, Random Forest and Artificial Neural Networks are used. A case study, forecasting the export volume of refrigerators and freezers from Turkey to United Kingdom is presented to demonstrate our proposed methodology. In this case study, 28 different factors are considered and the data (ranged from 2006 April to 2018 March) of each factor are obtained from various online data sources (OECD, International Trade Center, etc.). We demonstrated the effectiveness of our methodology on three sub-product of the main product type. The results showed that our methodology provides an accurate forecast on the export volumes. According to the results, both Random Forest and Artificial Neural Networks provide robust results. However, Random Forest performs better than the Artificial Neural Network to forecast demand export volumes.

Using feature selection, the important factors to forecast international trade volumes are also identified with our study. For all product types, Consumer Confidence Indicator has been seen as a dominant feature. Features related to Turkey's supply capacity and United Kingdom's demand capacity are also significant for all products types. The other features are product type specific and it shows the importance of the feature selection in the forecasting accuracy. Instead of using all features obtained from the data sources, using 50 percent of the features improves the forecasting accuracy for all products. Therefore, feature selection procedure improves the results for all products. The best forecast results are achieved by using different forecast horizons. Best forecast horizon for products 841840 and 841850 is four months and for product 841810 is six months. The reason for this difference may be the different market dynamics and seasonality structures of these products. The overfitting problem is mostly avoided by using hyperparameter tuning process. Therefore, this shows that the tuning process is a necessary step in machine learning methods and it helps to find better and more robust results.

For future work, our methodology can be tested on other export products for different countries. Differentiating significant factors affecting the forecast accuracy of different product groups is another possible extension of this work. In this study, Random Forest and Artificial Neural Networks are used. However, other machine learning methods, for example, Long Short Term Memory, can be employed to improve the forecast quality. Another research direction would be applying this methodology to other forecast areas in global supply chain management.

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ENDNOTE

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Chapter 5
A Handbook for ITF R&D Project Management

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ABSTRACT

Hong Kong's Innovation and Technology Fund (ITF) from the Hong Kong Special Administrative Region's Government supports collaborative R&D projects in industry, academia, and research centers. This chapter has been developed for the ITF project teams and collaborative organizations specifically, but it is a useful reference for project teams working with multiple partners or stakeholders. This chapter is the result of the author's Engineering Doctorate research on "Enhancing the Commercialization Success of Innovation and Technology Fund (ITF) R&D Projects in Hong Kong's Logistics and Supply Chain Industry." It takes the readers through the process from project identification to commercialization. The process described in the chapter has been effectively implemented in a recent ITF project in Hong Kong's logistics and supply chain industry. The chapter is a useful standard operations procedure (SOP) for collaborative R&D project teams.

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INTRODUCTION

This handbook complements the author's research topic on "An Analysis of the Determinants of Innovation and Technology Fund (ITF) R&D Projects Commercialization in Hong Kong's Logistics and Supply Chain Industries". The handbook provides hands-on practical advice, operation step, and temple for handling the phases of the cycle of ITF R&D projects. It is a standard operations procedures manual summarized the author's research finding in previous study. This study introduces the R&D ecosystem of Hong Kong Logistics and Supply Chain Industry. It included R&D Technologist side (Supply-side) and Industry side (Demand-side) stakeholders to push and pull the R&D deliverables to the Industry. The research conceptual framework foundation is based on six sigma model, DMAIC (Define, Measure, Analyze, Improve, and Control) (Six Sigma, 2017) for modification. The framework is divided in five phases as 1) Define Phase; 2) Development Phase; 3) Analysis Phase; 4) Solution Phase; and 5 Implementation Phase. This paper is focusing on the handbook of ITF R&D project and conclusion and limitation only.

RESEARCH CONCEPTUAL FRAMEWORK AND METHODOLOGIES

This study is formulated and conceptualized based on the findings in the literature review, quantitative and qualitative data analysis from R&D Technologist and Industry perspective in the author's previous research study, the data has been collected from the R&D Technologists, Industry Experts, Industry Users and piloted in a real case study. The whole research framework and methodology is established, but this handbook is summarized the findings in the red circle part of Figure 1.

The research conceptual framework is based on six sigma model, DMAIC (Define, Measures, Analyze, Improvement, and Control) concept to modify. Joseph and Mark (2014) redesigned the operation process to enhance the production. The key process and sub-tasks were listed on different stages one by one to solve the problem.

For critical analysis of the effectiveness of R&D process assessment for ITSP's R&D project development and commercialization in Hong Kong's Logistics and Supply Chain Industry. The research framework divided in two areas as R&D Technologist perspective and Industry perspective. The research study focuses on the expectation of R&D Technologist and Industry concern on the R&D project deliverables and value. The purpose is to identify the objectives for launching the efficiency monitoring mechanism for enhancing the R&D project effective and efficiency to commercialize and adopt to the industry. An integrated quantitative and qualitative study consists of both qualitative and quantitative research efforts. The research framework and methodology diagram is shown in Figure 1.

The research methodologies for this study are based on quantitative and qualitative analysis from both sides of R&D technologist and industry perspective. This research conceptual framework and methodology is focusing on 5 stages from Define, development, analysis, solution and implementation.

Phase 1 – Define Stage: Firstly, the study will identify the challenge of ITF's R&D projects and review Hong Kong's Logistics and Supply Chain trends. The R&D ecosystem, the role of R&D process in innovation, research milestones and research task will be defined.

Phase 2 – Development Stage: Secondary, citation of reference, theoretical framework, and hypothesis will be developed.

Phase 3 – Analysis Stage: Thirdly, the target survey group and questionnaire will be developed for collecting supply-side and demand-side perspective in both quantitative and qualitative analysis. This stage will interact with solution stage to test the hypothesis and model for solution development.

Phase 4 - Solution Stage: The data will be collected from different channel such as focus group survey, online data collection, and in-depth interview. Collect R&D Technologist and Industry User's expectation and concern to find out the key issue of R&D deliverables commercialization. Base on the analysis results to develop the proposition and evaluate the gap factors in between each development process.

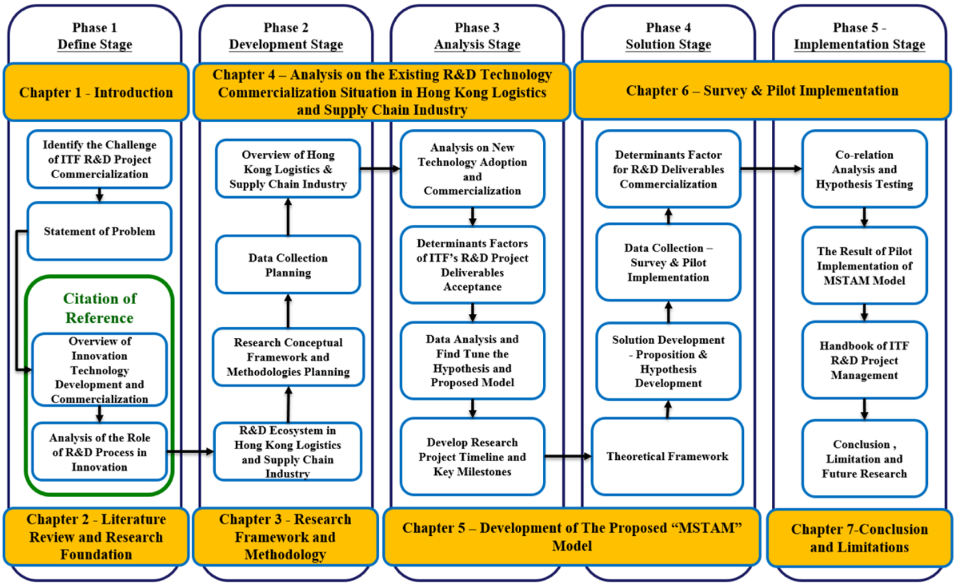
Phase 5 – Implementation Stage: Three case studies and a pilot implementation will be demonstrated to prove the hypothesis and proposed model can align with both supply-side and demand-side together to enhance the ITF R&D project deliverables commercialization and adoption rate to the market. The research conceptual framework and methodology operation step detail is listed in Figure 1.

This handbook is a part of the author's Engineering Doctorate Thesis and it presents the findings from the previous study in Phase 1 to Phase 5.

HANDBOOK OF ITF R&D PROJECT MANAGEMENT

ITF R&D project coordinator, project team and industry stakeholder are the primary target audience of this handbook. Project coordinator is a key member of ITF R&D project to manage and develop the R&D technology and product. The handbook is structured in 5 stages of the ITF R&D project development cycle. Each section

Figure 1. Research conceptual framework and methodology



describes the operation steps and critical project component need to be taken in terms of project identification, project preparation, design and planning, project implementation and monitoring, project review and evaluation, and impact assessment. This handbook is a reference for R&D Technologists and the stakeholder in the ITF R&D projects for easy handling the ITF R&D project from science stage to the market stage.

PROJECT IDENTIFICATION IN MARKET STAGE: INDUSTRIAL NEED

Before developing and overall plan of ITF R&D project and R&D technology, the R&D Technologist should identify the project type of the ITF R&D project first before start the preparation the project document. A comprehensive view of the project context and project type requirement, these are the first criteria of R&D project development. For instance: the research content, gist of the project, project scope, industry need, and what problem the project will be solved. The R&D project operation is suggested to the following steps:

Step 1: Define the Industry Need

Hadi et al. (2015) expressed that "*Clusters of actors are proposed in order to provide decision makers with a temporary and complementary organization designed for making efficiently simultaneous collaborative decisions*" The project initial stage have to be solved numerous issue before start the project for facilitating collaborative decision making among each stakeholders. The Dependency and Structure Modelling (DSM) approach is a square matrix based modelling to indicate the different tasks relationships in the project for the project investigator to prioritize the project tasks for arranging the most appropriate deployment. James Moultrie (2015) proposes to solve the barriers and create the benefits in science exploration stage, the designers should work closely to the scientists to identify the critical part and bottle neck points in advance for pushing the project forwards.

Step 2: Explore R&D Solution

Noemie et al. (2016) stated that the most project management approach is to maximize the values of the project. A detailed project planning needs to be addressed to break down all the critical tasks and sub-tasks of the project. . The most important dimension of project tasks such as time limit, resources constraints need to be addressed and prioritized for increasing the project value. A Concept Formulation is proposed in the project initiative stage. Steven et al. (2002) stated the commercialization of disruptive technology for the new firm was preferred to use market-pull strategies and source from both sides of exogenous and firm core competences technology to define the type of innovation and market strategies for user application. To emphasis the commercialization opportunity, the market pull strategies are preferred.

PROJECT PREPARATION, DESIGN AND PLANNING IN SCIENCE STAGE: RESEARCH AND DEVELOPMENT

The second stages of the project identification, the project needs to be properly prepared, designed, and planned. The ITF R&D project design defines the main components of the projects, including overall project deliverables, project aims to be addressed, innovation and technology component, technical capability, existence of a holistic plan to realization and commercialization, and beneficiaries for the Industry. The project coordinator and project team should identify the problem statement first to explore the idea to solve the practical industry problem. The design section may be conducted in multiple steps, address the problem statement and define the research content, especially for technical challenges, operational challenges, and organizational challenge. The handbook constitution important pillars and integral part of a R&D project proposal.

Step 3: Prepare Proposal

Dwi Al Aji et al. (2016) expressed that Key Performance Indicator (KPI) and SMART criteria (Specific, Measurable, Achievable, Relevant, Time-bound) are the good tools to determine bonus to the employee base on their performance based weight calculation. Prathamesh et al. (2016) suggested SMART approach to enhance the quality of the program to synchronization among all the activities. It structures a systematic way to use various assessment tools to test whether the listed outcome are reliable. Time management should be properly structured to eliminate the improper information of program. Barry et al. (1995) stated "*Requirements Engineering, is a time consuming, expensive but critical phase in software (and system) development*". SMART requirement is proposed for specifying requirements specification of the development to correct the incorrect and incomplete information. This can be made it measurable. Summarized the literature review and ITSP (2017) guideline, the proposal check list detail is listed in Table 1.

Step 4: Seek Industry User Support

Kamil and Ali (2014) studied the problem of the industry with its constraints at the beginning for the engineering problem. It helps the researcher to acquire the industry information and skills in the right direction to create the new technology for solving the real issue of industry. Also S. Franken et al. (2016) also expressed that "meets the end user's needs is the goal of every software development process", if the early feedback and expectation from the end users have been collected before development. The additional cost can be eliminated. Uda and MIMOS (2002) stated that the proposal is a decision point whether the project will start or determine in the early development stage. Therefore, Industry Users support in the project initial stage is essential and necessary.

Step 5: Set Out All Critical Activities of ITF R&D Project

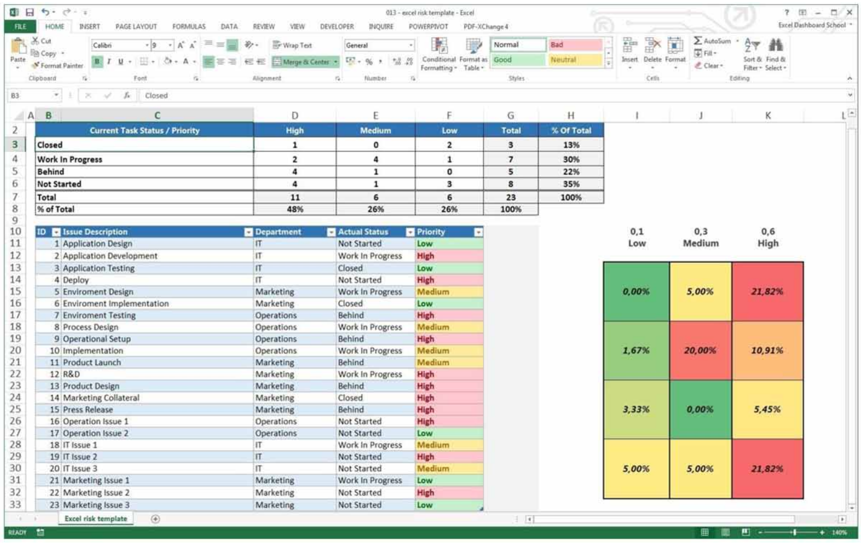
Yanjun and Jun (2014) through Design Structure Matrix (DSM) model using computer experiments to examine the project issue of scheduling interrelated activities in sequence for identifying what problems with minimum the total communication time and solving the relevant small problem tasks occurs to avoid the big challenge happen in future. Daniel et al. (2014) suggested DSM approach to be used in

Table 1. ITF R and D proposal check list

Item	Description	Specific (S)	Measurable (M)	Assignable (A)	Realistic (R)	Time-related (T)
1	Project Title	✓	N/A	N/A	N/A	N/A
2	Project Summary	✓	✓	N/A	✓	✓
3	Project Deliverables	✓	✓	✓	✓	✓
4	Location of R&D work	✓	✓	✓	✓	✓
5	Project Milestones	✓	✓	✓	✓	✓
6	Innovation and Technology Component	✓	✓	✓	✓	✓
7	Technical Capability	✓	✓	✓	✓	✓
8	Project Expenditure	✓	✓	✓	✓	✓
	● Manpower	✓	✓	✓	✓	✓
	● Equipment	✓	✓	✓	✓	✓
	● Other Direct Cost	✓	✓	✓	✓	✓
	● Administrative Overheads	✓	✓	✓	✓	✓
	● Industry Sponsorship / Other sources of Financial Contribution	✓	✓	✓	✓	✓
9	● Project Income	✓	✓	✓	✓	✓
10	Existence of a Holistic Plan to Realisation / Commercialization	✓	✓	✓	✓	✓
11	Relevance with Government Policies or in Overall Interest of the Community	✓	✓	✓	✓	✓
12	IP Rights and Benefit Sharing	✓	✓	✓	✓	✓
13	Management Capability	✓	✓	✓	✓	✓
14	Methodology	✓	✓	✓	✓	✓
15	Supporting Document	✓	✓	✓	✓	✓
16	Technical Justification	✓	✓	✓	✓	✓
17	Budget Justification	✓	✓	✓	✓	✓

early stage of complex systems to identify the uncertain information and changes request in the early development stage of the project. The DSM approach provides 4 categories application such as component-based, team-based, activity-based, and parameter-based to prioritize the complexity metrics relationship of each project tasks in the project for speeding up the development process. Table 2 is the project risk management template to prioritize the risk at the proposal stage.

Table 2. Excel project risk management template



Current Task Status / Priority	High	Medium	Low	Total	% Of Total
Closed	1	0	2	3	13%
Work In Progress	2	4	1	7	30%
Behind	4	1	0	5	22%
Not Started	4	1	3	8	35%
Total	11	6	6	23	100%
% of Total	48%	26%	26%	100%	

ID	Issue Description	Department	Actual Status	Priority
1	Application Design	IT	Not Started	Low
2	Application Development	IT	Work In Progress	High
3	Application Testing	IT	Closed	Low
4	Deploy	IT	Not Started	High
5	Enviroment Design	Marketing	Work In Progress	Medium
6	Enviroment Implementation	Marketing	Closed	Low
7	Enviroment Testing	Operations	Behind	High
8	Process Design	Operations	Work In Progress	Medium
9	Operational Setup	Operations	Behind	High
10	Implementation	Operations	Work In Progress	Medium
11	Product Launch	Marketing	Behind	Medium
12	R&D	Marketing	Work In Progress	High
13	Product Design	Marketing	Behind	High
14	Marketing Collateral	Marketing	Closed	High
15	Press Release	Marketing	Behind	High
16	Operation Issue 1	Operations	Not Started	High
17	Operation Issue 2	Operations	Not Started	Low
18	IT Issue 1	IT	Work In Progress	Medium
19	IT Issue 2	IT	Not Started	High
20	IT Issue 3	IT	Not Started	Medium
21	Marketing Issue 1	Marketing	Work In Progress	Low
22	Marketing Issue 2	Marketing	Not Started	High
23	Marketing Issue 3	Marketing	Not Started	Low

0,1 Low	0,3 Medium	0,6 High
0,00%	5,00%	21,82%
1,67%	20,00%	10,91%
3,33%	0,00%	5,45%
5,00%	5,00%	21,82%

PROJECT IMPLEMENTATION AND MONITORING IN TECHNOLOGY STAGE: PRODUCT EXPLORATION

When industry requirement and market need have been collected in the third stage of the project implementation and monitoring in technology, a systematic management system is needed to monitor the project process and find tuning in the technology stage to explore the project deliverables to meet the original planning. James Moultrie (2015) stated the progressing scientific theory from laboratory to commercialization. The basic categories are divided in three stages of basic research, applied research and experimental development. Between the applied research and experiments development, the design demonstrators should demonstrate the technical feasibility of potential applications, visual applications, and scale-up the physical size of the technology in the future. Consequently, a project monitoring mechanism and early warning system are the critical tools for checking the R&D progress.

Step 6: Project Monitoring Mechanism

Daniel Howard (2009) proposed Program (Project) Evaluation and Review Technique (PERT) method to solve the complexity project tasks scheduling problems for the user to determine which activities are "Critical" and in sequence. Alireza et al. (2013) states the nowadays popular project management tool is business process modelling and expresses this model using five criteria as pattern, framework, usability, expressiveness, and scalable to identify each project tasks composition for prioritizing the project tasks in the R&D process. Therefore, project lead time, project scope, project tasks, project schedule and updated project status are the KPI for monitoring the project progress. Table 3 & Table 4 are the project milestones & deliverables tracking template for the R&D technologist to easy follow which project tasks need to be implemented. PERT is a common technique used in conjunction with the Critical Path Method (CPM) for scheduling a set of project activities for helping the R&D Technologist to plan and monitor the project.

Step 7: Early Warning System Template for ITF R&D Project

In the project implementation stage, the project should be regularity monitored to track the project development status and R&D deliverables performance in both internal and external factors. Florian and Orestis (2014) expressed that "*A deep analysis of the Critical Success Factors for the strategic management of radical technological innovations is sensible*." If the critical success factors of the project are clearly identified that can leading the project to success. Noemie et al. (2016) expressed to maximize the project values such as time, cost, and resource constraints and different interaction factors relationship, it should be evaluated the combination of each critical factors of the project for project scheduling.

Table 3. Project milestones tracking template

No.	**Milestones** - Description - with period start date & completion date	**Tasks** - Description - with period start date & completion date	Jan 18 -Jun 18	Jul 18 – Dec 18	Jan 19 – Jun 19	Jul 19 – Dec 19	**Status (Completed / Ongoing / Delayed)**
1	Task 1						
2	Task 2						
3	Task 3						
4	Task 4						
5	Task 5						
6	Task 6						
7	Task 7						
8	Task 8						
9	Task 9						
10	Task 10						

Table 4. Project deliverables tracking template

No.	**Deliverables** - Description - with period start date & completion date	**Tasks** - Description - with period start date & completion date	Jan 18 -Jun 18	Jul 18 – Dec 18	Jan 19 – Jun 19	Jul 19 – Dec 19	**Status (Completed / Ongoing / Delayed)**
1	R&D deliverable 1						
2	R&D deliverable 2						
3	R&D deliverable 3						
4	R&D deliverable 4						
5	R&D deliverable 5						
6	R&D deliverable 6						
7	R&D deliverable 7						
8	R&D deliverable 8						
9	R&D deliverable 9						
10	R&D deliverable 10						

During the project development period, regular monitoring and tracking actions are needed. Summarized the above finding and Project Operations Manual (2016), a systematic early warning system is a good guide to exam the project tasks in which level. The detail is listed in Table 5.

Table 5. Early warning system template for ITF R and D project

Warning Level	Description of Scale Value and Use in Reporting
Accepted Level	1. Executed according to the project milestones
	2. Execution in progress according to the plan and will be fully implemented by the set deadline
Attention Level	3. Executed with delay
	4. Not executed in accordance with the plan, but it is in progress and will be executed fully by due date – the end of the year
Alarm Level	5. Not implemented in accordance with the plan but it is in progress and will be fully implemented after due date
	6. Not started yet, but is expected to start with the measure/activities until due date, or after due date
	7. The activity cannot be implemented
	8. Activity dismissed

PROJECT REVIEW AND EVALUATION IN APPLICATION STAGE: TECHNOLOGY IMPLEMENTATION

Project review and evaluation is an essential check point in the R&D project to review whether the R&D progress is matched with original planning. Periodically project inspection and evaluation of pilot implementation for the R&D project are important components of the project. Thence, inspection and evaluation tasks are needed in the application stage.

Step 8: Inspection of ITF R&D Project

Leonardo and Thomas (2005) proposed a multi dimension model to evaluate the uncertainly within the product development life cycle and deals with different difficult factors in the project all together. To secure the value and performance of the project deliverables, regular project review and evaluation among each key transaction processes start from prototype stage to test stage, analyze stage, improve design stage, make a compact system stage, and finally to the market, these control work is necessary. Within each product development phases, inspection and project evaluation are essential work to ensure the product quality to meet the original requirements from the market.

C. Hollauer et al. (2014) proposed an Engineering Change Management (ECM) model to improve the generation, transfer and application of knowledge in the company for learning the mistake from the past for solving the issues between people and technology. Wenbo and Huaqi (2015) proposed a project risk evaluation index system to identify the risk factors in the R&D project. The detail of source of risk, risk factors, risk indicator and life cycle for the entire R&D project, these risk elements should be listed in detail for evaluating one by one. It can easy to locate which index in high risk. To sum up the captioned findings, a detail R&D inspection check list is needed for the inspector to test the specification progressively.

Table 6 is an inspection check list template for ITF R&D project for setting out the issues to be covered during the project review and progress meetings to facilitate monitoring of the projects by project inspector. In recording or reporting the meetings and findings, project inspector should make reference to the checklist if appropriated.

Step 9: Evaluation of Pilot Implementation - Validated the “Proof-of-Concept”

Michael and Stephen (2013) proposed a system dynamic approach for IT adoption in a complex environment. This approach describes the operation flow from the potential adopters to former adopters and conducted three-fold experiments such

Table 6. Inspection check list template for ITF R&D projects

Inspection Check List					
No	**Description**	**Product Performance (Accepatable / Fail)**	**On Time (Y/N)**	**Within Budget (Y/N)**	**Remark**
1	**Project Deliveables**				
	Deliverable 1				
	Delievrable 2				
	Deliverable 3				
	:				
2	**Project Milestones**				
	Task 1				
	Task 2				
	Task 3				
	:				
3	**Budget**				
	Manpower Item 1				
	Manpower Item 2				
	Manpower Item 3				
	:				
	Equipment Item 1				
	Equipment Item 2				
	Equipment Item 3				
	:				
	Other Direct Cost Item 1				
	Other Direct Cost Item 2				
	Other Direct Cost Item 3				
	:				
4	**Commercialization Plan**				
	Activitie 1				
	Activitie 2				
	Activitie 3				
	:				
5	**Document**				
	Progress Report				
	Final Report				
	Annual Audited Account				
	Fina Audited Account				
	Technical Specification				
	Prototype Testing Results 1				
	Prototype Testing Results 2				
	Final Testing Result				
	:				

as base experiments, sensitivity analysis experiments, and “what-if” experiments, to validate the concept. Michael et al. (2017) used a System Readiness Assessment (SRA) approach to evaluate whether a larger system is readiness for comparing with alternatives designs using same application approach and assessment tool. This approach evaluates the data from each sub-system technology to calculate their current level of performance. The system evaluation criteria are identified to three testing level, such as Systems Readiness Level (SRL), Technology Readiness Level (TRL) and Integration Readiness Level (IRL), it validated whether these technologies are well prepared. Saleh et al. (2016) proposed the technology readiness assessment for the user adoption, it should be identified and investigated the readiness factors for end users in order to validate whether the technology accepted by the end users.

The inspector or project team should follow the inspection check list (Ref: Table 6) to inspect the project tasks one by one regularly and evaluate which items or tasks have the high risk in the project. To define all the risks in development and application stage that can be enhanced the quality of work and avoided any discrepancies occur in the project period to ensure the project deliverables are in right quality, right time, right place and right cost for fulfilling the industry standard.

IMPACT ASSESSMENT IN MARKET STAGE: COMMERCIALIZATION

Impact assessments for the ITF R&D project are a final stage of Handbook of ITF R&D Project Management. This is an important bridge between R&D Technologist and Industry User to communicate together enhancing the technology transfer and commercialization opportunity to the market. It is a systematic analysis to let the end users to provide the feedback to the developer for lasting changes or provide the positive / negative feedback in the pilot.

Step 10: Finalize the Developed Technology Specification - Verification and Validation

Seo-Kyun Kim et al. (2009) investigated the technology commercialization factors for SMEs in IT-related business. The study focuses on three areas of the company, these are R&D capabilities, technology commercialization, and innovation performance. Within the innovation project development cycle, six commercialization-related variables were suggested to measure whether the performance of the developed technology is value-added and competitive advantages for the company. Theses variables are 1) Learning Function; 2) R&D Function; 3) External Networking Function; 4) Manufacturing Function; 5) Marketing Function and 6) Product Competitiveness. Hence, verification and validation of the performance of the developed technology is a critical step in the project development cycle. Bin and Fei (2018) proposed verification and validation approach for system design to verify its functionality and architecture in detail for analyzing the system performance base on the design description. Johannes Bach et al. (2018) proposed that "*To assure the feature under development's valid behavior, the sample of scenarios evaluated for Verification and Validation (V&V) needs to proof substantial coverage of all possible situations*." Summarized the above findings, finalize the developed technology specification for

Verification and Validation to assure the developed technology performance and functionality are workable.

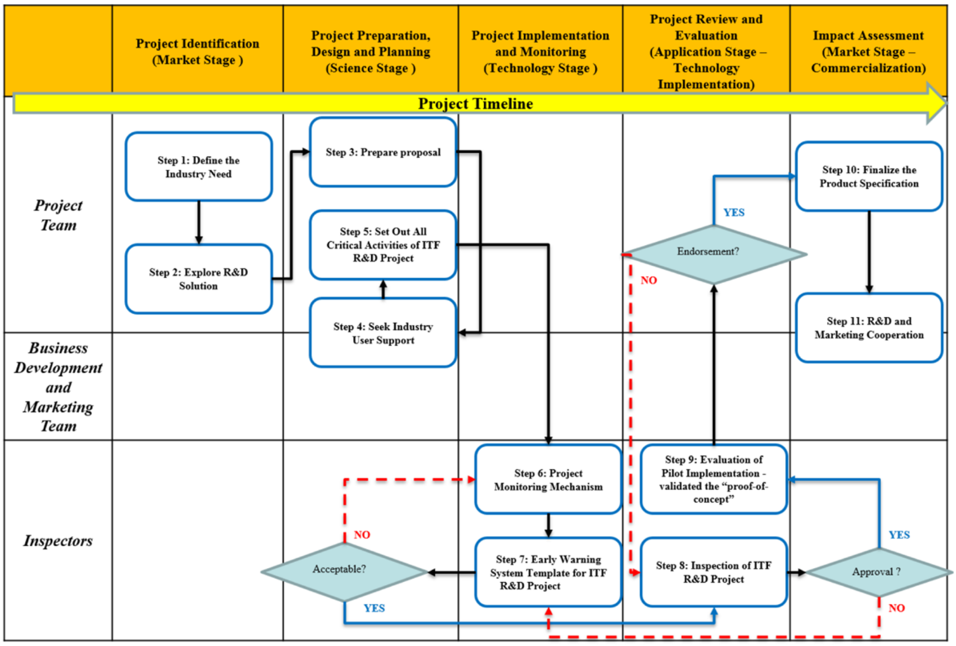
Step 11: R&D and Marketing Cooperation

Abram Hernandez (2006) stated that the market demand is continuous increasing. A high degree specialization of the product is needed for linking R&D and Marketing together. This is a critical factors in New Product Performance (NPP) for playing an active role to align the goals of the company to promote the developed product to the market more efficiency and effectiveness. Antonino and Sven (2013) proposes a business model concept for boosting the rate of adoption of the new technologies to the market. The model is including value proposition, competencies, channels and customer relations, value added structure and processes, network and partners, and revenues. It can create a great benefit for the company via the technology marketing. Also, the rate of adoption of new technology can be increased. J F Cowles (1995) stated "*Develop a comprehensive understanding of the needs, wants and behaviors of existing client and potential customers*." The marketing function is a vital role for facilitating the engineer to break the gap to the customer. Seo-Kyun Kim et al. (2009) expresses the external networking function and marketing function are the important variables influencing on innovation performance for the firm to commercialize the technology to the market. The literatures are suggested that R&D and Marketing cooperation can increase the rate of R&D deliverables adoption in the market. Figure 2 is the proposed standard operations flow for handling the ITF R&D projects in different stage. This optimization process is to guide the R&D Technologist to perform the operation smoothly.

CONCLUSION AND DISCUSSION

Qualitative and quantitative of the data collected from R&D Technologists and Industry User have been carried out against a proposed project management model, MSTAM in the author's previous research. This is the first of the multi-perspective study to bridge the gaps from idea generation, R&D and subsequent technology implementation and adoption by industry. For the traditional ITF R&D project operation mechanism has many monitoring procedure and operation step to examine the R&D project progress. But the mechanism may be ignored the R&D deliverable whether suitable apply to the industry in a reasonable time, need and fulfil the expectation of industry and R&D technologist. Complicated and long project time schedule are the key issues affect the R&D technology transfer to the industry. Industry need and R&D technology applied research may need to be aligned. This

Figure 2. Typical process to perform ITF R and D Project management optimization



study summarized the previous finding into a handbook for all stakeholders easy to follow and manage the ITF R&D projects.

SUMMARY OF RESEARCH FINDINGS

This research objective is to find out the solution for addressing the problems in the ITF R&D project. The main reason and major barriers of ITF R&D deliverables commercialization and adoption issues, action for motivating to the industry users, key considerations for the industry users to adopt the new technology, and appreciate actions for the industry adopt developed R&D deliverables are addressed through the multi-perspective study to various stakeholders including R&D Technologists, System Integrators, Industry Experts, and Industry Users. Through a pilot implementation in real case RD project to demonstration the developed approach are workable. The author investigates both supply side view and demand side perspective of stakeholders in Logistics and Supply Chain Industry in Hong Kong for collecting their expectation and concern for detail analysis of ITF R&D project deliverables commercialization and adoption to the industry. Evaluating and studying the key issue and bottle neck point in the development process through the quantitative and qualitative survey from R&D Technologist, Industry Experts and Industry Users. In order to understand both supply side and demand side attitude towards the adoption of the R&D technology to their company, primary and secondary data are evaluated.

The research finding for the ITF R&D project commercialization to the industry is a new attempt to address the different barrier in the development process. It is subject to four factors such as control, time, quality, and motivating to influence of R&D technology commercializing and adopting to the market in the effective ways. Finally, the research results are proved that provide a clear picture of ITF R&D project management for commercializing the R&D technology in a systematic framework. This handbook is a good reference for all stakeholders to have a clear picture to work together in the ITF R&D project for pushing up the alignment.

RECOMMENDATIONS FOR FUTURE RESEARCH

This handbook is a working tool for all project managers to manage ITF R&D project for Logistics and Supply Chain Industry in Hong Kong. The research is proposed to define the industry need at the beginning and then step by step to work with the industry user and system integrator to develop the technology and apply to the industry in systematic way. More research is required in analysis of existing R&D technology in different areas in the world. This handbook would be provided a better assistance and help to the universities, research institutions, R&D companies and R&D Centres in the R&D development of new technology commercializing to the market. Further attempts and trial implementation may need to be applied in the different ITF R&D projects such as platform, collaborative, and public sector trial projects by using this handbook. Finally, this study established a concrete framework and foundation to let all R&D stakeholders to have a clear picture in the R&D process. It can help to all stakeholders manage the project smoothly and ensure the developed technologies are more suitable for the industry and fulfil in industry need.

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Chapter 6
Forecasting:
Investigating the Structural Relationship Among Financial Ratios and Stock Prices

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ABSTRACT

The chapter covers a study on forecasting stock prices, which can be a challenging task due to the amount of information and variability involved. The test approach, research, and results cover 50 companies on the US stock market over a 6-year period. Company quarterly and annual financial reports, along with daily stock prices, form the data set analyzed. The financial ratios were tested as independent variables against stock price as the dependent variable. Also, ratio type comparisons and timing scenarios for leading or lagging indicators were covered. Correlation and multiple-regression tests were used to eliminate some ratios, and to find a combination of 12 ratios that successfully account for 35% of the variability in stock prices. The results point to leading indicators, statistically significant ratios, and a predictive model for forecasting stock price.

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INTRODUCTION

General Summary

The purpose of this study is to identify which financial ratios are more relative to the daily stock price in order to develop predictive modeling. Ample data is available for publicly traded companies, including their financial reports, fundamental ratios and stock prices. The research is intended to analyze the relationships between financial ratios and stock price, ratios to ratios, and the timing of information.

Financial Reports of publicly traded companies are submitted to the Securities Exchange Commission (SEC) on a quarterly and annual basis, in the forms of 10-Q and 10-K reports. According to the SEC, “The quarterly report includes unaudited financial statements and information about the company’s business and results for the previous three months and for the year to date. The annual report includes the company’s audited annual financial statements and a discussion of the company’s business results.” (U.S. Securities Exchange Commission, 2019, para. 3).

Components of these reports are the Balance Sheet, Income Statement, and Statement of Cash Flows, which together reflect the financial condition of the company. Financial analysts use numerous financial ratios, derived from figures in the 10-Q and 10-K reports, to determine the health and challenges of the company. There are several categories of financial ratios that cover different aspects of the business and how the company performs: Profitability, Liquidity, Efficiency, Leverage, and Valuation.

Problem Statement

Many of the financial ratios are derived from the 10-Q and 10-K reports. A few financial ratios change daily, for example, by moving with the market price per share. An example of this is the Price/Equity (PE) ratio. While the Equity value, established in the 10-Q and 10-K, holds that value until the next report, the Common Stock Price/market price per share does change daily. This creates a ratio that is half positioned on a quarterly basis, while the other half of the ratio fluctuates daily. These ratios will be referred to as FR2 type ratios. The rest of the financial ratios are fixed for the quarter, that is, all values are tied directly to the 10-Q or 10-K and will be referred to as FR1 type ratios.

The problem statement is that many of the financial ratios only update, or catch up as a lagging indicator, when the 10-Q and 10-K are posted, while a few data points move daily (reactively or in anticipation of market news, company opportunity, changes in the overall market, etc.). This lead/lag of information can be averted, in predictive modeling, by determining which financial ratios best correlate to the company stock price, at various points in time. This allows the ability to predict an expected range for the stock price, according to historical trends with the strongest correlated ratios.

Not all financial ratios are created equally. All are valuable for specific aspects of a company status or performance, with some that tell a specific part of the story and some that tell the broader story. An example is the Return on Equity (ROE) ratio, which draws from figures at the bottoms of both the Balance Sheet and Income Statement. Considering that the bottom figures (of the Balance Sheet and Income Statement) represent the company financial results, the ROE ratio would tell the broader story. Conversely, the Quick ratio draws from figures at the top, and only from the Balance Sheet. Therefore, the Quick ratio would tell a specific story of the company performance.

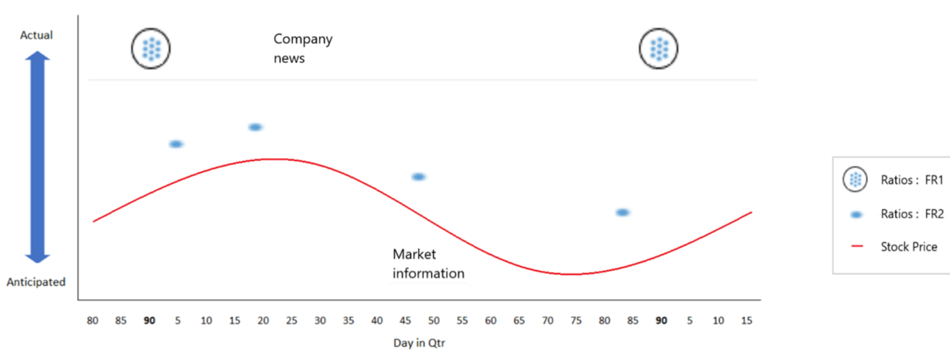
Analysis would help determine which categories of ratios, and which specific ratios, have the strongest correlations to price and are most useful for predictive modeling.

This graphic illustrates the timeline relationship between the reports (10-Q or 10-K), the associated Financial Ratios (FR1 and FR2), and the stock price. Company reports are published at the end of each quarter, and at the same time the (FR1) fixed financial ratios are set, later followed by those floating (FR2) financial ratios tied to the stock price.

RESEARCH HYPOTHESES

The goals of hypotheses herein are to first, establish which ratios may be best utilized for stock price predictive modeling; second, to establish the relationships of both ratio types and ratio hierarchies, based upon test results; and third, to establish

Figure 1.



relationships of Lead-Lag conditions. The ratio hierarchical and Lead-Lag results will apply toward future research of those topics.

Correlation Between Ratio and Stock Price

One hypothesis is that the FR2 ratios (ratios linked to the daily stock price) will have stronger correlation and higher statistical significance than the FR1 ratios (ratios bound to the quarterly reports, and not linked to the daily stock price). Certain ratios, from FR1 and FR2 groups, will be strongly correlated and have statistical significance to the stock price. It should be noted that correlation can be used to characterize dependencies using pairs, and two variables are said to be independent when the value of one cannot provide meaningful information about the value of the other (Altman & Krzywinsky, 2015; Essila, 2018).

Ratio Types and Hierarchy

An inherent hierarchical relationship is expected to surface from the test results, which would show that ratios derived toward the bottom of the Balance Sheet and/or Income Statements would have stronger correlation to and statistical significance for stock price prediction.

Similarly, certain ratio types, such as Profitability ratios, would be expected to have stronger correlation to and statistical significance for stock prices than those of Efficiency, Liquidity, or Leverage. An example would be a company that has excellent inventory management controls and efficiently turns over assets/products; however, the company is very unprofitable. The Profitability ratio should have stronger correlation to and statistical significance for the stock price than the Efficiency ratio would have to the stock price.

Lead-Lag Correlations

The null hypothesis for Lead-Lag tests is that forward and backward-looking stock prices do not have stronger correlation and statistical significance.

Hypotheses

Ho1: Ratio **Price to Earnings** (PE) does not (statistically) significantly impact the Stock Price.

Ho2: Ratio **Price to Book Value** (PB) does not (statistically) significantly impact the Stock Price.

Ho3: Ratio **Price to Sales** (PS) does not (statistically) significantly impact the Stock Price.
Ho4: Ratio **Earnings per Share** (EPS) does not (statistically) significantly impact the Stock Price.
Ho5: Ratio **Return on Equity** (ROE) does not (statistically) significantly impact the Stock Price.
Ho6: Ratio **Total Asset Turnover** (TAT) does not (statistically) significantly impact the Stock Price.
Ho7: Ratio **Fixed Asset Turnover** (FAT) does not (statistically) significantly impact the Stock Price.
Ho8: Ratio **Operating Income ROI** (OIRIO) does not (statistically) significantly impact the Stock Price.
Ho9: Ratio **DuPont Equation** does not (statistically) significantly impact the Stock Price.
Ho10: Debt Ratio does not (statistically) significantly impact the Stock Price.
Ho11: Financial Leverage ratio (FLR) does not (statistically) significantly impact the Stock Price.
Ho12: Ratio Times Interest Earned (TIE) does not (statistically) significantly impact the Stock Price.
Ho13: Current Ratio does not (statistically) significantly impact the Stock Price.
Ho14: Quick Ratio does not (statistically) significantly impact the Stock Price.
Ho15: Cash ratio does not (statistically) significantly impact the Stock Price.
Ho16: Ratio **Return on Assets** (ROA) does not (statistically) significantly impact the Stock Price.
Ho17: FR2 ratios do not have higher significance than **FR1** ratios do.
Ho18: A 3-Qtr stock price offset (Price Before) for ratios does not have stronger correlations.
Ho19: A 3-Qtr stock price offset (Price After) for ratios does not have stronger correlations.

LITERATURE REVIEW

Stock Prices

Stock prices are determined by the supply and demand of what the buying and selling market is willing to pay for a stock. The NYSE and NASDAQ both have Market Makers, those who are either specialists or member firms, and their role is to facilitate the flow of stock transactions. They do this by setting the Bid (buy) and Ask (sell) prices for stocks and by buying and selling a stock continuously so transactions are flowing. “A ‘market maker’ is a firm that stands ready to buy and sell a particular stock on a regular and continuous basis at a publicly quoted price.” (U.S. Securities Exchange Commission, 2019, para. 3). According to the NYSE, “Designated Market Makers (DMM) have obligations to maintain fair and orderly markets for their assigned securities. They operate both manually and electronically to facilitate price discovery during market opens, closes and during periods of trading imbalances or instability.” (New York Stock Exchange, 2019, para. 2).

While the information from the Quarterly and Annual reports is used by Analysts and Market Makers, to help determine the value of the stock, there is not a direct formula from those reports that determines the stock price tomorrow and so forth. Similarly, other factors like market and industry information, economic and tax information also helps to determine the value of the stock, and stock price, throughout the quarter. The market makers use this information (and possibly mis-information) as input to setting the bid/ask prices.

Financial Ratios

Financial ratios can be used to compare performance and financial health between companies or to trend an individual company over time. All publicly traded companies listed on stock exchange platforms such as the NASDAQ (National Association of Securities Dealers Automated Quotations) or NYSE (New York Stock Exchange) are required to submit financial statements to the SEC (Securities and Exchange Commission). These financial statements are the Quarterly and Annual reports (10-Q and 10-K, respectively). Included in these are the Balance Sheet, Income Statement, and Statement of Cash Flows. The companies submit their reports to the SEC data platform EDGAR (Electronic Data Gathering, Analysis, and Retrieval). This platform performs automated collection, validation, indexing, acceptance, and forwarding of submissions by companies and others who are required by law to file forms with the U.S. Securities and Exchange Commission (U.S. Securities Exchange Commission, 2012).

The financial ratios can then be derived from a singular report or combination of the Balance Sheet, Income Statement, and Statement of Cash Flows. The ratios describe a company’s Profitability, Liquidity, Efficiency, Leverage/Debt, and market Valuation. As well, there can be secondary ratios, that is, a ratio derived by comparing ratio to ratio. An example would be the DuPont Formula, which uses Net Margin, TAT (Total Asset Turnover), and FLR (Financial Leverage Ratio) for a composite measure of company efficiency.

Profitability ratios show how well a company can turn investments, assets and sales into profits.

Return on Equity (ROE) = Net Income/Owners' Equity
Return on Assets (ROA) = Net Income/Total Assets
Operating Margin = EBIT/Sales
Net Margin = Profit/Revenue

Liquidity ratios provide information on how a company is positioned to cover any immediate short-term or long-term liabilities due to creditors or banks and suppliers.

Current ratio = Current assets/Current liabilities
Quick ratio = (Current assets – Inventory)/Current liabilities
Cash ratio = Cash and Cash equivalents/Current Liabilities

Efficiency ratios measure how well a company operates using their inventory, assets, and resources.

Total Asset Turnover (TAT) = Net sales/Total assets
Fixed Asset Turnover (FAT) = Sales/Fixed Assets
Operating Income ROI (OIROI) = EBIT/Total Assets
DuPont Equation = Net Margin*TAT*FLR

Leverage ratios measure how a company is positioned with the use of debt financing.

Debt Ratio = Total Liabilities/Total Assets
Financial Leverage Ratio (FLR) = Total Assets/Equity
Times Interest Earned (TIE) = EBIT/Interest Expense

Valuation ratios provide measures between the company market cap size, earnings, etc. in relation to the stock price to provide insight to market value. Ratios derived using the stock price or market cap will therefore change daily, as compared to ratios that only draw from quarterly or annual statements.

Dividend yield ratio = Dividend per share/Share price
Earnings per share ratio = Net earnings/Total shares outstanding
Price-earnings ratio = Share price/Earnings per share
Price to sales ratio = Price/Sales

Relationships Between Financial Ratios and Stock Prices

The research of Eugene Fama and Kenneth French (1995) on the NYSE, AMEX, and NASDAQ 1963-1992 found the ratios of Market Equity and Book Equity to Market Equity capture much of the cross-section of average stock returns. They also stated, "In a rational market, short-term variation in profitability should have little effect on stock price and book-to-market-equity; BE/ME should be associated with long-term differences in profitability." (Fama & French, 1999, p. 24) Therefore, increased long-term profitability would rationally be associated with increases in stock price.

Mohammad Razdar and Morteza Ansari (2013), in their research of 66 companies for a period of five years on the Tehran Stock Exchange, found a positive relationship between each ratio, independently, for Gross Profit Margin, Return on Assets, and Return on Equity, when analyzed against stock price (pp 9-12). They further suggested that it is better to select companies with higher Gross Profit Margin, Return on Assets, or Return on Equity for investment (p.13).

Nissim and Penman (1999) studied ratios for benchmarking and forecasting, looking at cross-sectional variation and correlation and using data from NYSE and AMEX 1963-1996. Results included large t-statistics and reasonable R square values in estimation; however, models performed poorly in prediction out of sample, and they recognized the similar findings of Ou and Penman (1995) (p. 23). Nissim and Penman (1999) stated an interesting perspective that "the traditional DuPont analysis ties the ratios together in a structured way. This algebra not only explains how ratios 'sum up' as building blocks of residual income but also establishes a hierarchy so that many ratios are identified as finer information about others." (p. 2)

A study of the Egyptian stock market by Omran Ragab (2014) analyzed 46 companies over a five-year period, looking at linear and non-linear relationships between financial ratios and stock price. Three models used included multiple regression for linear relationships, bivariate models, and multivariate models of non-linear relationships. The findings were that the linear model showed Return on Equity was the only important determinant of stock returns. However, Return on Equity stood out in all the models as a significant determinant (p.18).

Obala and Olweny (2018) analyzed the 10 banks in the Nairobi Securities Exchange for a period of five years, using multiple regression analysis. Their findings are that Current Ratio and Return on Assets hold a moderate but positive influence on stock returns (p. 7). They acknowledge the findings align with the previous research of Anwaar (2016), Issah (2015), and Nurah and Ghassan (2015).

Petcharabul and Suppanunta (2014) analyzed the Stock Exchange of Thailand from 1997 to 2011 for relationships between ratios and stock return. They found from OLS regression analysis that only Return on Equity and Price to Earnings are positively significant at 95% confidence level (p. 7).

A study done by Gilang Pradipta similarly tested the influence of several ratios and the effect on stock price in the Indonesian Stock Exchange from 2009 to 2011. Those ratios were Current ratio, Debt to Equity, Return on Assets, Return on Equity, and Gross Profit Margin. Pradipta's (2012) findings were that t-test indicates that CR, ROE, and GPM negatively and significantly influence dependent variable, which is stock price. DER and ROA positively and significantly influence stock price (p.22). Although that research involved 19 companies, the observation period was limited to just a few years.

METHODOLOGY

Data and Research Sample

The data used for this project was sourced from Quandl, a NASDAQ company (www.Quandl.com). All U.S. stock market data going back to 2009, from 10Q/10K postings to the SEC, including financial ratios, daily stock price, and more, is available. A selection of financial ratios was used as the Independent Variables, while the daily stock Closing Price was used as the Dependent Variable. Six years of data, 2013 – 2018, for 50 companies was extracted and equates to approximately 76,000 data points. The posting date of the quarterly financial reports was used and aligned with the Closing Price for the same date.

Similar market sectors and industries were identified and used to select the 50 companies for the data sample set. This was to avoid wild variations which could significantly affect one company or a set of companies and skew the analysis. For instance, companies in the Technology sector could be materially impacted by advances in technology, especially over a six-year span, when compared with commodity companies. The 50 companies represent Utilities (water, electric, gas and waste), Energy (generation and distribution) and Precious Metals.

RESEARCH METHODS AND PROCEDURES

This quantitative analysis is of a descriptive design, measuring the association between the dependent and independent variables of a large data set. The scale of measurement used is the interval scale, as the financial ratios and stock price are, or are reflective of, U.S. dollars. Therefore, all companies' information is comparable, whether in the form of actual dollars or ratios. It should be noted that correlation can be used to characterize dependencies using pairs and two variables are said to be independent when the value of one cannot provide meaningful information about the value of the other (Altman & Krzywinsky, 2015; Essila, 2018).

Tools used to complete the analysis and support the findings were Correlation, Multiple Linear Regression, and ANOVA (Analysis of Variance). Correlation tests were used to identify and exclude ratios with insignificant correlation to the stock price, using a cutoff value of 0.80 as considered large (Mason & Perreault, 1991). A single factor ANOVA analysis was used to test assumptions toward the predictive model, with the stock Closing Price as the Dependent variable and the ratios as the independent variables in the hypothesis testing. Analyses for Goodness of Fit (Significance F <.05 alpha), Good Model depending on the expected outcomes and a classical Statistical Significance (P-value <.05 alpha) were completed and the results are shown below.

Test Cases

Test 1: Individual ratios, FR1 and FR2 groups
- ◦ 16 FR1 ratios get tested as a group
- ◦ 4 FR2 ratios get tested as a group
- ◦ Analysis for Goodness of fit, Good model, and Statistical significance

Test 2: Combined FR1 and FR2, passing results from Test 1
- ◦ Ratios with P-values >.05 alpha are eliminated and tests are conducted again

Test 3: Lead-Lag, passing results from Test 2
- ◦ Ratios with P-values >.05 alpha are eliminated
- ◦ Offset Stock Price by 3 report periods [9 months], Forward of ratio [date]
- ◦ Offset Stock Price by 3 report periods [9 months], Backwards of ratio [date]
- ◦ Correlation tests to identify ratios with significantly increased/decreased correlation

Test 1 Results

Figure 2 and Figure 3 show the results for Test 1.

Results

- Correlation results show a narrow range for all Ratios to Price.
- Goodness of Fit and Good model tests pass in all cases.
- Statistical significance tests pass for 12 of 20 ratios.

Figure 2.

Correlation measures

	Correlation to Price	
EPS	0.08718	*Very weak pos*
ROA	0.07220	*Very weak pos*
PS	0.06856	*Very weak pos*
Operating Income ROI (OIRIO)	0.05514	*Very weak pos*
ROE	0.03380	*Very weak pos*
DuPont Equation	0.03376	*Very weak pos*
PE	0.02262	*Very weak pos*
PB	0.01017	*Very weak pos*
Dividned Yield	0.00951	*Very weak pos*
Return on Revenue	-0.00553	*Very weak neg*
Net Margin	-0.00673	*Very weak neg*
Operating Margin	-0.00742	*Very weak neg*
Fixed Asset Turnover (FAT)	-0.01772	*Very weak neg*
Financial Leverage Ratio (FLR)	-0.02221	*Very weak neg*
Times Interest Earned (TIE)	-0.05217	*Very weak neg*
Asset Turnover (TAT)	-0.08699	*Very weak neg*
Debt ratio	-0.11473	*Very weak neg*
Cash ratio	-0.14917	*Very weak neg*
Quick Ratio	-0.21679	*Very weak neg*
Current ratio	-0.24060	*Weak neg*

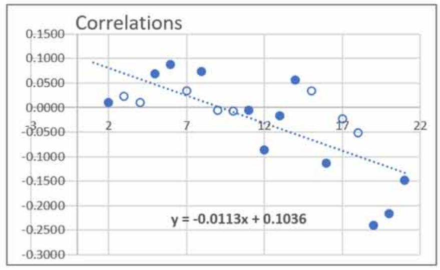


Figure 3.

	Goodness of Fit	*Good Model*	*Statistical Sig.*
FR1 Group	Significance F	R-Square	P-values
1st run	9.710E-130 ✓	0.30945 ✓	6 eliminated
2nd run	5.170E-115 ✓	0.27191 ✓	
FR2 Group			
1st run	9.710E-130 ✓	0.30945 ✓	2 eliminated

- 8 ratios were eliminated based upon P-values
- *ROE, DuPont Equation, Return on Revenue, Financial Leverage Ratio (FLR),*
- *Times Interest Earned (TIE), PE, PB*
- 12 ratios continue to the next set of tests

Test 2 Results

Figure 4 and Figure 5 show the results for Test 2.

Results

- Goodness of Fit and Good model tests pass.
- R-Square moves up to 35%.

Figure 4.

Regression Statistics		
Multiple R	0.59497	
R Square	**0.35398**	**35%**
Adjusted R Square	0.34962	
Standard Error	18.29719	
Observations	1788	

ANOVA	*df*	*SS*	*MS*	*F*	***Significance F***
Regression	12	325617.211	27134.768	81.051	**1.022E-158**
Residual	1775	594246.957	334.7870181		
Total	1787	919864.1679			

	Coefficients	*Standard Error*	*t Stat*	***P-value***	*Lower 95%*	*Upper 95%*
Intercept	49.231	2.230	22.080	1.188E-95	44.858	53.604
Dividend Yield	67.814	20.642	3.285	**1.039E-03**	27.329	108.298
PS	5.082	0.342	14.871	**3.134E-47**	4.412	5.753
EPS	9.636	0.607	15.873	**3.684E-53**	8.445	10.827
ROA	-303.909	58.964	-5.154	**2.832E-07**	-419.555	-188.263
Net Margin	-10.028	2.025	-4.953	**8.007E-07**	-14.000	-6.057
Asset Turnover (TAT)	-92.681	15.416	-6.012	**2.217E-09**	-122.916	-62.447
Fixed Asset Turnover (FAT)	39.788	7.575	5.253	**1.680E-07**	24.932	54.645
Operating Income ROI (OIRIO)	130.129	49.121	2.649	**8.140E-03**	33.789	226.470
Debt ratio	-18.316	3.525	-5.196	**2.269E-07**	-25.229	-11.402
Current ratio	-9.768	1.360	-7.181	**1.016E-12**	-12.435	-7.100
Quick ratio	-6.761	1.504	-4.496	**7.362E-06**	-9.710	-3.812
Cash ratio	8.893	2.058	4.322	**1.633E-05**	4.857	12.929

Figure 5.

FR1 & FR2 Combined

Significance F	R-Square	P-values
8.036E-157 ✓	0.34816 ✓	all pass ✓

- Statistical significance tests pass for all 12 ratios.
- Data suggest that a mathematical model for predicting stock price is:

Y = 67.8 X1 + 5.1 X2 + 9.6 X3 - 304 X4 - 10 X5 - 92.7 X6 + 39.8 X7 + 130.1 X8 - 18.3 X9 - 9.8 X10 - 6.8 X11 + 8.9 X12

Figure 6.

Where Y is the Stock Price

X1 is the Dividend Yield
X2 is the PS
X3 is the EPS
X4 is the ROA
X5 is the Net Margin
X6 is the Asset Turnover (TAT)
X7 is the Fixed Asset Turnover (FAT)
X8 is the Operating Income ROI (OIRIO)
X9 is the Debt ratio
X10 is the Current ratio
X11 is the Quick ratio
X12 is the Cash ratio

Test 3 Results

Figure 7 and Figure 8 show the results for Test 3.

Results

- Price Before Ratio tests had considerable changes in correlation.
- Price After Ratio tests had minimal changes in correlation.

Figure 7.

Change in Correlation	PRICE	Price Before Ratios	Price After Ratios	Variance: Price Before Ratios	Variance: Price After Ratios
Dividend Yield	0.08	0.18	0.08	**116%**	-8%
PS	0.31	0.24	0.28	-22%	-8%
EPS	0.28	0.22	0.29	-21%	0%
ROA	0.13	0.08	0.14	**-35%**	4%
Net Margin	0.17	0.12	0.17	**-30%**	
Asset Turnover (TAT)	-0.26	-0.27	-0.25	6%	-3%
Fixed Asset Turnover (FAT)	-0.23	-0.24	-0.22	7%	-4%
Operating Income ROI (OIRIO)	0.11	0.06	0.11	**-43%**	
Debt ratio	-0.11	-0.12	-0.09	6%	-15%
Current ratio	-0.31	-0.30	-0.32	-6%	3%
Quick ratio	-0.29	-0.29	-0.28		-3%
Cash ratio	-0.19	-0.19	-0.20		5%

Figure 8.

Regression Statistics	
Multiple R	0.24351
R Square	**0.05930**
Adjusted R Square	0.05672
Standard Error	19.90553
Observations	1469

ANOVA	*df*	*SS*	*MS*	*F*	*Significance F*
Regression	4	36564.061	9141.015	23.070	**1.642E-18**
Residual	1464	580081.110	396.230		
Total	1468	616645.171			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	34.378	1.034	33.240	0.000	32.350	36.407
Dividend Yield	176.402	24.510	7.197	**9.78E-13**	128.324	224.480
ROA	235.836	57.120	4.129	**3.85E-05**	123.790	347.883
Net Margin	7.604	1.984	3.832	**1.33E-04**	3.711	11.496
Operating Income ROI (OIRIO)	-233.345	51.200	-4.558	**5.61E-06**	-333.778	-132.912

- 1 ratio, Dividend Yield, had significant favorable changes in correlation.
- 3 ratios, ROA, Net Margin and OIRIO, had significant unfavorable changes in correlation.
- Continued research on these 4 ratios is recommended based upon the variability over a leading 9-month period.

(Note: A favorable result in correlation change would be either an increase in a Positive variable, or a decrease in a Negative variable).

PRACTICAL AND MANAGERIAL IMPLICATIONS

Practical implications from this study, for individual investors and academics alike, include a way to remove unnecessary information, in the form of financial ratios, when evaluating a company's stock price. The work in ratio hierarchy can also provide a better understanding of which ratios can best represent efficiency, leverage, and liquidity. While there are many ratios available to use, knowing which have statistical significance for each area will provide better guidance.

A managerial implication could be that this research may assist companies to be better informed where their efforts toward company change and improvements may best be served, that is, in how the stock price would respond, according to the predictive model. Improved portfolio planning for investor institutions and simplification for their clients on their investment data is possible.

CONCLUSION

This research project set out to understand differences in financial ratios, how the stock exchange operates (timing and use of data, market-makers and price-setting, etc.), to determine valuable sources of data, to break down and analyze a six-year data set of 50 companies, and to conduct a series of tests to achieve a statistically significant predictive model using financial ratios to predict stock price. These items have been completed successfully. One challenge was obtaining access to a good data source that had everything available in one stop, and at a reasonable cost (academic accounts ranged from $99 per Qtr. to $1,200/yr.). Another (expected) challenge was the amount of data organization and spreadsheet work required. Specific conclusions are as follows.

Correlation Between Ratio and Stock Price: The tests satisfied correlation and ANOVA, and P-value results were much smaller than the alpha value .05 for 12 ratios. Therefore, the Null Hypothesis is rejected, and the 12 ratios are significant. Eight ratios were eliminated.

Ratio Types and Hierarchy: FR2 ratios, those with stock price as a factor in their ratio, do not dominate the 12 ratios in the results and the null hypothesis stands.

Lead-Lag Correlation: A 3-Qtr stock price offset (Price Before) resulted in several ratios with significant changes in correlation measures. Dividend Yield correlation to stock price increased, favorably, by 116% for the leading 3-Qtr period. ROA, Net Margin, and Operating Income ROI (OIRIO) correlations to stock price decreased, unfavorably, by 35%, 30%, and 43%, respectively. The 3-Qtr stock price offset (Price After) did not result in any considerable changes in correlation measures.

Progressing through the series of tests, the ANOVA and R-Square measures improved, and the P-values became more statistically significant. Twelve ratios in combination account for 35% of the variance of stock price for these 50 companies over a six-year period.

A valuable predictive model can now be used and tested, along with creating a test investment portfolio to match. Questions were answered about ratio types, hierarchies and lead-lag conditions, which can all be used toward future research.

FUTURE RESEARCH

Repeating the study and testing all common ratios can be done to strive for a combination of ratios above an R-Square measure of 35%. Additional testing of the ratios identified in the Leading correlation tests can be done, using more and less leading Qtrs., to see if there is a better timing indicator than 3-Qtrs. Further analysis of the ratio hierarchy is recommended. Testing can be done on individual stocks, using the predictive model established here, to determine the delta between the stock's actual price and predicted price, for investment opportunity (of course, with other considerations toward investments).

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Chapter 7
Leadership 5.0 in Industry 4.0:
Leadership in Perspective of Organizational Agility

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ABSTRACT

In today's competitive environment, agile firms tend to be more successful. If today's technology companies, which are leaders in their sector, may fail in that competitive environment, it would be possible that they might lose their market leadership in the future. Some companies which were in the top in market in their own sector in the past are likely to be stand back from their competitors for not adapting to market change conditions. Fast process of technology and digital world are taking place in all organizational authoritative in all area and in all kind of sectors because the business world is transformed by the postmodern revolution-Fourth Industrial Revolution. In this dynamic environment, leaders should learn new management behaviors, with which they can communicate both internal and external environment of their enterprises by the strategies of being agile and innovative organizations. This can be by being aware of changes in environment and having the ability to manage these changes for the company's favor.

INTRODUCTION

Fast process of technology and digital world are taking place in all organizational authoritative in all area and in all kind of sectors, because the business world is transformed by the postmodern revolution-Fourth Industrial Revolution. In this dynamic environment, leaders should learn new management behaviors, with which

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they can communicate both internal and external environment of their enterprises by the strategies of being agile and innovative organizations. This can be by being aware of changes in environment and having ability to manage these changes for the company's favor.

Change is an indispensable fact of our lives. Change happens in organizations, in people behaviors and ideas and in every area of the world we live in. In particular, the continuous changes in customers' demands and needs make it inevitable for managers and leaders of companies to constantly adapt to these changes in order to keep their firms in a competitive environment. Leaders and managers have sought new solutions in order to manage and to survive their enterprises in dynamic and changeable business environment. For that, they firstly focused on adaptation, then on flexibility and finally they focused on agility, especially in production in order to adapt to change. Especially after 2000s, this change has been getting increased and for companies it has been inevitable to be agile organizationally.

We live in a digital time, and in this time, most of the people are in communication with the technology itself instead of each other. The changes in this time force leaders and managers to understand both changes and developments in the environment and to adapt those changes to their enterprises. Kouzes and Posner (2003a) state that leaders and managers are expected to have four qualities such as vision, trust, courage and knowledge in order to achieve this adaptation.

Today's business environments are changing at an extraordinary rate (Günsel & Açikgöz, 2013). In today's competitive environment, agile firms tend to be more successful. If today's technology companies, which are leaders in their sector, may fail in that competitive environment, even it would be possible that they might lose their market leadership in the future. Because some companies which were in the top in market in their own sector in the past are likely to be stand back from their competitors for not adapting to market change conditions. Some of these firms have not had high market share which they had in the past, although they keep their surviving. It may be said that one of the main reasons of these companies losing their leadership in their sector is to fail meeting customers' needs and demands. Companies need to develop their structures and processes according to customers' demands, by taking into consideration variables in both internal and external environment in order to get competitive advantage and maintain their market position. Therefore, agility is quick turning into a key driver for organizations additionally as an important issue to a firm's ability to survive and thrive in uncertainty market (Ganguly et al., 2009).

Organizational agility, which has been used in the field of production, was first systematized in the literature of organization and management in 1990s and after that has been used in different fields. For example, organizational agility has been studied in the field of human resources (Shafer, 1997), in the field of production (Lopes, 2009), in terms of sustainable competition (Mason, 2010) and in the performance of employees (Latham, 2014). However, the important question here is there a relationship between multiple leadership styles and organizational agility? Even no study is seen in literature that examine the relation between multiple leadership style and organizational agility in techno-enterprise firms which create technology and mostly need to adapt changes in environment in industry 4.0 term. This gap in literature leads us to focus on this basic research question in our study whether "Multiple leadership styles in techno-enterprise firms have an effect on organizational agility or not?"

Organizations need a leader to reach their goals, to maximize their profit and value, to overcome chaos, turbulent and incomprehensible situations and the leaders have been able to rescue organizations from these adverse situations with the least harm and also they have been able to maintain their organizations presence. Throughout history, different leadership approaches and styles have been defined by different researchers. The multiple leadership approach, one of these approaches, will be discussed in this research.

Leadership and Historical Background of Leadership

The concept of leadership is as old as humanity history. Many kinds of leadership have been occurred during history in military system, organization and enterprises. For business, the concept of leadership became increasingly important, especially, after the industrial revolution period which stable market environment and competitive pressure existed. Leadership may sometimes be confused with some terms such as *power, authority, management, administration, control, and supervision* (Yukl, 2010). There are numerous definitions of leadership in literature. In this context leadership has been defined in terms of traits, behaviors, role relationships, or direction position. But it can be minimized with some common definitions as below:

- It is a behavior of an individual (Hemphill & Coons, 1957),
- It is a process of direction (Jacobs & Jaques, 1990),
- It is the ability to influence and motivate others (House et al, 1991),
- It is the ability to start evolutionary change processes (Schein, 1992).

As it is understood through the definitions above, leadership is a concept on that is important for the effectiveness of organizations. It may be hard to survive without leadership for an organization and every member should be a leader in today's dynamic environment of organizations (Ekren, 2014).

In social sciences leadership is among the popular widely studied topics. The literature has organized the theories of leadership into five categories: (1) trait (2) behavioral (3) contingency and (4) leader-member exchange (5) contemporary leadership. It is important to understand the historical development of these theories to see how modern theories align with the contemporary nature of business and organizations.

Trait Theories of Leadership

Trait theories of leadership, rooted in the "Great Man" of the 18^{th} and 19^{th} centuries, center on the personal characteristics that differ leaders from non-leaders (Kirkpatrick and Locke, 1991; Bryman, 1992). It has the belief that leaders are born not made and individuals have qualities which make them more effective leaders.

Behavioral Theories of Leadership

Behavioral theories of leadership, being focused on late of the 20^{th} century, consider leader behaviors as factors in deciding leadership effectiveness. It has belief that effective leaders, such as laissez-faire, autocratic or democratic leadership, differ from ineffective leaders based on defined behaviors of action. The three most popular cited behavioral leadership studies are the University of Michigan Studies (Likert, 1967), The Managerial Grid (Blake and Mouton, 1970) and the Ohio State University studies (Bass & Stogdill, 1990).

Contingency Theories of Leadership

Contingency theories of leadership, being popular in late of the 21^{st} century, described leadership in terms of leader behavior. Employers, task and culture of an organization and particular environment may lead the leadership effectiveness. Fiedler (1967) stated that high performing groups are occurred when a leader's natural style fits the situation or characteristics of organization. The three most popular models of contingency theories of leadership have been met in literature. Least Preferred Co-Worker (LPC) identifies leaders as either oriented toward human relations or tasks. The Path-Goal theory suggests that the role of the leader is to explain goals and provide the path and resources for followers to achieve those goals (House, 1971). Situational Leadership Model imply the factors of task behavior, leadership behavior to determine the effectiveness of the leader and consider that leaders should focus more on relationships and less on tasks (Hersey et al., 1988; Deckard, 2009).

Leader-Member Exchange Theories of Leadership

Leader-Member Exchange Theories of Leadership (LMX), paralleling with contingency theories of leadership in late of the 21^{st} century, describes that leadership does not occur in a vacuum, it is characterized by the interdependence of leaders, followers and organized groups (Gooty et al., 2012). The theories focus specifically on the mutual relationship between individual leaders and followers (Graen & Uhl-Bien, 1995). Leader-member exchange theories also suggest that leaders develop close relationships with members.

The Contemporary Leadership Approach

Multiple leadership styles, with its emphasis on the relationship between leaders and followers, are rooted in the concepts described in leader-member exchange theory.

This term, which is considered to be beyond the situational approach by the researchers, is named the "Contemporary Leadership Approach" and the term leader is used referring to mean "farsighted" (Sashkin, 1988), "charismatic" (Conger & Kanungo,1988; House,1977) and "transformational" (Bass,1985; Bass and Avolio,1994).

Burns (1978) was the first person using the term transformational leadership, one of type of multiple leadership styles. Since then, multiple leadership approach has drawn attention all over the world that has been studied in different disciplines. He described transformational leadership as a process in which leaders and followers engage in a mutual process of raising one another to higher levels of morale and motivation (Burns, 1978). Transformational leaders lead their followers towards long-term goals instead of short-term ones and motivate them toward self-realization. This kind of leader prefers intrinsic rewards, rather than materialistic rewards and relies on a personal value system (Lewis-Kunhert, 1987; Gibson & Donnelly, 1994). Multiple leadership styles play an important role in the success of present-day organization; multiple leadership approach includes three leadership styles called transformational, transactional and laissez faire leadership.

Transformational Leadership

Burns to begin with presented the concept of changing authority in his expressive inquire about on political pioneers, but this term is presently utilized in organizational brain research. According to Burns (1978), changing authority may be a handle in which "*leaders and followers help each other to advance to a higher level of morale and motivation*"(p.425). Kuhnert and Lewis (1987) stated that the transformational leader links an organization's vision to the aims and personal standards of its employees. Such leaders prefer internal tools to reward their employees, rather than material values and they are based on personal value systems (Kuhnert & Lewis, 1987). Transformational leaders based on these values have features. These features are expressed as follows by (Tichy&Devanna, 1986):

- They are visionaries seeing themselves as change agents,
- They are leaders taking risks,
- They believe in the people in their organization,
- They learn from their experiences
- They overwhelm uncertainty which brought by change.

In industry 4.0, transformational leaders thanks to these features play a crucial role in managing this change in today's businesses where change happens fast.

Transactional Leadership

Mutual interest relationship is very important between transactional leader and his/her followers. If the leader meets the needs and expectations of their followers, they will perform the demands of the leader. Therefore, it may be said that in the transactional leadership understanding, the effectiveness of the leader depends on the extent to which the changing needs of followers. The interaction between followers and the leader is based more on moral values and the interaction between followers and the leader is based on the material and external rewards such as salary increase, permission (Kuhnert & Lewis, 1987:649). As Tichy & Devanna (1986) stated that "Transactional leaders are concerned about a more stable environment with slight competition".

Laissez-Faire Leadership

In multiple leadership approach, transformational and transactional leaders are mostly compared with laissez-faire leadership styles (Bass and Stogdill, 1990). Laissez-faire leaders hesitate to decide or take positions, hesitate to act, hesitate to use their authority, and often disappear when they are needed. Each of these leadership styles stated above has its own components. These components are shown in Table 1.

ORGANIZATIONAL AGILITY AND ABILITIES

Organizational agility is a main concept for organizations in today's competitive and fast-changing market environment (Bessant et al., 2002; Goodhoue et al., 2009). It enables an organization to adapt efficiently, rapidly and accurately way in fast-changing market environment (Ganguly et al., 2009). It is about reaction and adaptation to changes which driven by customers, competitors and technology. It shows that change is a key aspect of organizational agility.

Table 1. Multiple leadership styles and components

Transformational Leadership	Transactional Leadership	Laissez-Faire Leadership
Idealize Influence-Attitude Leaders are admired, respected, and trust.	*Contingent Reword* Leaders get agreement on what needs to be performed, and promise rewards in exchange for carrying out the agreement between leaders and followers.	*Laissez-Faire* Leaders are inactive, ineffective and nothing is transacted.
Idealize Influence-Behavior Leaders demonstrate high standards of ethical and moral conduct.	*Management by Exception-Active* Leaders arrange to actively monitor deviances from standards, mistakes, and errors in the follower's agreement and to correct mistakes and errors when necessary.	
Inspirational Motivation Leaders motivate and inspire their followers.	*Management by Exception-Passive* Leaders keep waiting for deviances, errors and mistakes to occur and then correct them.	
Intellectual Stimulation Leaders stimulate their followers 'perform to be more innovative and creative.		
Individualized Consideration Leaders pay special attention to each individual's needs for achievement as coach.		

There are many researches and studies related to adaptation of organizational structure and processes to changing environmental conditions in the field of management organization, and also researches have been conducted on how organizations have coped with ambiguity and change by adaptation to environmental conditions (Burns & Stalker, 1961; Hage& Dewar, 1973). Competition is no longer local, but global, technology is getting more evolved, environment is changing rapidly and industrial environment is developing more. That's why enterprises must be agile in order to manage their environment and to survive in dynamic and competitive environment. In order to get over these problems, leaders have tried to find new solutions. For that, firstly they focused on adaptation, then on flexibility and finally they focused on agility, especially in production in order to adapt to these changes. As a natural consequence of this, the concept of organizational agility can be stated as rapidly change and adapt in response to changes not only in the production department but in all departments of firms.

Organizational agility, which was used in the field of production in 1990s and after that has been used in different fields, is a new concept so it has not a common definition, but it is defined as an organization capability to respond rapidly to market changes by Breu et al. (2001). Organizational agility is the manufacturer's ability to react quickly to sudden and unpredictable changes (Putnik, 2001). Organizational agility can be also explained as the ability of the enterprise to respond quickly to unforeseen and unexpected changes in business internal and external environment. In other words it can be defined as the ability of an organization to respond as fast as to changing competitive conditions

Organizational Agility Abilities

Organizational agility has its own characteristics and abilities. To tell whether an enterprise or organization is organizationally agile, it must have some capabilities. The organizational agility model usually has an identical structure consisting of three elements. These are (Sharifi & Zhang, 1999:11; 2001:775):

- "Agility Drivers" which are defined as the way in which the enterprises operate (the pressures which force enterprises to adapt the changes in the business environment, the need for agility, the strategic intent to be agile and agility strategy).
- "Agility Capabilities" which are explained as the organizational agility of the business (these are the skills required for businesses to respond positively to the changes in business environment, consisting of four dimensions; responsiveness, competence, flexibility, and speed).
- "Agility Providers" which mean that administrators/managers use the agility capabilities of the business (practices that are necessary for agility skills to be acquired).

Although there are some differences in opinion in different researchers in the literature, Sharifi & Zhang (1999), Zhang & Sharifi(2000), Sharifi et al. (2001), Crocitto & Youssef (2003), Lin et al. (2006), Shahaei, (2008), Zhang (2011), Nejatian & Hossein Zarei (2013), Mohammadi et al. (2015) state that organizational agility has four basic abilities; Responsiveness, Competence, Flexibility and Speed.

Responsiveness

This ability is stated to be the first ability of a business organizational agility (Sharifi & Zhang, 1999; 2001), Sharifi et al. (2001), Crocitto & Youssef (2003), Lin et al. (2006), Shahaei (2008), Zhang (2011), Nejatian& Hossein Zarei (2013), Mohammadi et al. (2015). It is the ability to be aware of the changes in the market, and the ability to react these change quickly.

Due to technological and environmental changes, customer demands and needs may change over time. Businesses must respond to these changes on the right time and right place. If they respond to those changes, they could gain a competitive advantage. This is due to the fact that the business being agile organizationally and using its responsiveness ability.

Flexibility

Because of the rise of this concept are the globalization of markets, there has there been significant attention on flexibility (Günsel & Açikgöz, 2013). The ability of a business to be flexible means to adapt to environmental changes (Sanchez, 1993), to reach the optimum size and to respond continuously to unexpected changes (Kundi and Sharma, 2015). Flexibility can be stated that a business adaptation its own structure and resources to change, to increase its market share or to create new product and technology. Moreover it can be stated the ability of a business to re-change its internal resources (employees, machines, equipment, architectural structure, etc.) according to the demands and needs of the customers. If it were succeeded, the enterprises could maximize its profit.

Speed

There is a strong relation between speed and responsiveness. As a matter of fact, some researchers (Sharp et al., 1999; Gunasekaran & Yusuf, 2002; Lin et al., 2006; Jain et al., 2008) stated that after having decided how to react to the changes, businesses should be able to apply these decisions quickly. It is the ability to complete an activity as quickly as possible (Zhang &Sharifi, 2000), in other words, is the ability to do an activity as soon as possible (Christopher, 2000) or the ability to respond quickly to changes in the environment of the business (Hoyt et al., 2007; Shahaei, 2008). Speed, which can be explained as the ability of a business to deliver the product or service effectively and in short time, is quite important for a business in aspect of innovation abilities, improving a new knowledge against change.

Competence

The competence dimension of organizational agility can be stated as the ability of using the other three abilities (Responsiveness, Flexibility, and Speed) of organizational agility. Because the ability of a business to carry out, an event is related to its ability to use its competence. Competence is the ability and capacity to renew existing or potential skills to adapt a business to changes in environment (Teece et al., 1997) or the ability to reach business goals effectively and efficiently (Sharifi& Zhang, 1999).

Studies about Multiple Leadership Styles and Organizational Agility

There are some researches about organizational agility and leadership styles in literature. But most of them are related with leadership styles and agile production, job satisfaction, organizational success, performance or service quality (See Table 2).

As mentioned above, these researches are mostly about agile production, job satisfaction, organizational success, performance or service quality and especially about transformational leadership style, which is only a style of multiple leadership styles. However, there are limited studies discussing multiple leadership styles,

Table 2. Studies about multiple leadership styles and agility

Researcher	Year	Topic	Result
Zhang &Sharifi	2000	A methodology for achieving agility in manufacturing organizations	A model has been identified and an organizational agility model has been designed to provide agility in the manufacturing sector.
Tetik	2008	The Role of transformational leader in managing change	The transformational leader has an important role in managing change.
Xu et al.	2008	The impact of transformational leadership style on organizational performance: The intermediary effects of leader-member exchange	The results show that the transformational leader increase organizational performance.
Hüseynov	2010	The role of organizational agility in Strategic management of human resources	Strategic management of human resources is important to create organizational agility.
Judkrue	2012	The influence of transformational leadership style on organizational success: A study on MNCs in Bangkok, Thailand	The results show that transformational leaders can increase employee performance in multinational companies.
Young	2013	Identifying the impact of leadership practices on organizational agility	The results show that leadership style increases organizational agility in the service sector .
Chou	2014	Does Transformational Leadership matter during Organizational Change?	The results show that transformational leaders affect employees' behaviors supporting change directly.
Veiseh et al.	2014	A study on ranking the effects of transformational leadership style on organizational agility and mediating role of organizational creativity	The results show that transformational leaders have effect on organizational agility.
Karimi et al.	2016	The Effect of Transformational Leadership Style on Components of Organizational Agility in Isfahan University of Technology	The results show that transformational leadership style effect on organizational agility dimensions.

consisting of transformational, transactional and laissez faire leadership related with organizational agility in literature, in other words the discussing the interaction between these two components.

TECHNOLOGY AND SCIENCE PARKS

In Industry 4.0 terms, science parks (techno parks) have a critical role for organizational agility which is inevitable for them. These parks also create technology by itself, which is one of the most important components in industry 4.0. Technology can be defined as to create a product, to transform an existence product or service to another new one. So it can be said using and improving of technology has an aim. As Burgelman (1991) said that the enterprises create new marketing and technologies to introduce new services and products, to meet customers' demands (p.240). Thus, by using technology to meet both customer's needs and expectations and new market demands, the enterprises can transform their own resource and organizational structure (Brown & Eisenhardt, 1995:343).

It may be said that the enterprises can create new markets by offering new products and services that meet customers' demands and expectations. They can do it with some abilities such as to be innovative, adaption to change and respond to this change. Furthermore they can do it easier and faster with the technology. This is a dynamism which is more common in techno parks where technology is very intense. As known, the first technopark was founded in the prior of Stanford University in California. In Turkey, one of the countries which pay attention to technology, the first project for developing of technoparks started at the beginning of 1990s. By then, the number of technoparks increased in a short time and by May 2016 the number of technoparks increased to 69 and the number of companies conducting R&D in techno parks was about 4,510 (www.tgbd.org.tr, 18.03.2018). This rapid increasing in the number of companies shows that the technoparks are successful. Those companies contribute to both the region and the country's economy. In addition, these companies operate in different sectors such as software sector, computer and communications, electronics, machinery and equipment, medical, energy, chemical, food, defense and automotive (See Table 3).

The statistical information given above shows that the number of technoparks and the number of people working in these companies are rather high.

In order to determinate the relationship between multiple leadership and organizational agility, 31 managers were interviewed in science parks in Dokuz Eylül University Technoparks by Akkaya (2018). Akkaya (2018) used MAXQDA qualitative data analysis program to analyze this relationship in his doctoral dissertation. According to the results of this dissertation most of those managers have

Table 3. Sectorial distribution of firms operating in the technoparks in Turkey

Sector of Activity	Average Numbers	Percentage (%)
Software Sector	1668	37
Computer and Communication	767	17
Electronic	361	8
Machinery and equipment,	271	6
Medical, Energy, Chemistry, Food, Defense, Automotive	1443	32
Total	4.510	100

Source: http://www.tgbd.org.tr (18.03.2018).

transformational leadership behaviors. The strong relation is between transformational leadership and organizational agility. While transactional leadership has also slight relationship with organizational agility, laissez-faire leadership has no relation with it (Figure 1). He also used SPSS to analyze the correlation between dimensions of multiple leadership styles and organizational agility components (See Table 4). Those quantitative results also confirmed qualitative results seen in

Figure 1. Multiple leadership styles and organizational agility relation

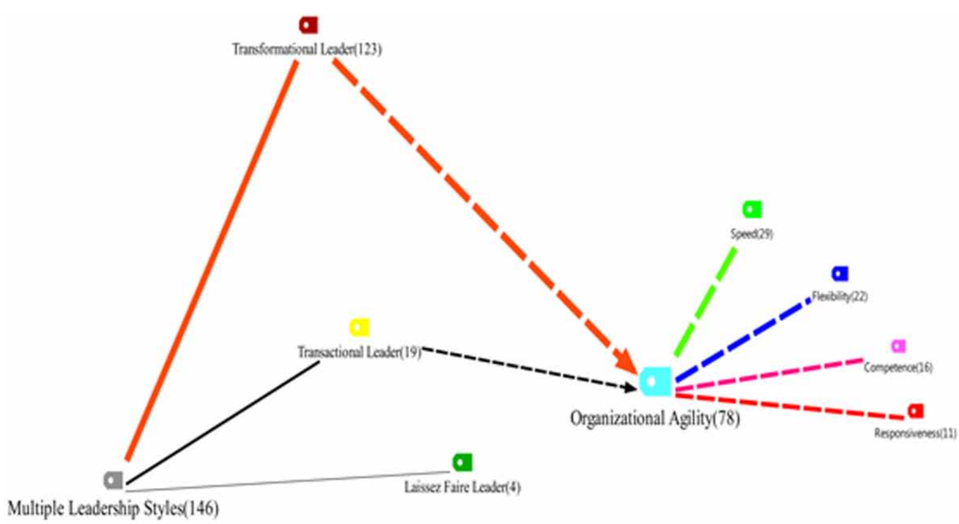

Table 4. Correlations between multiple leadership styles and organizational

	Components	Inspirational Motivation	Idealized Influence-Attitude	Idealized Influence-Behavior	Individualized Consideration	Intellectual Stimulation	Contingent Reward	ME-A	ME-P	Laissez Faire	Competence	Flexibility	Responsiveness	Speed
Transformational Leadership	Inspirational Motivation	1												
	Idealized Influence-Attitude	,501*	1											
		,000												
	Idealized Influence-Behavior	,536*	,499*	1										
		,000	,000											
	Individualized Consideration	,485*	,537*	,448*	1									
		,000	,000	,000										
	Intellectual Stimulation	,523*	,460*	,434*	,545*	1								
		,000	,000	,000	,000									
Transactional Leadership	Contingent Reward	,508*	,617*	,427*	,499*	,507*	1							
		,000	,000	,000	,000	,000								
	ME-A	,366*	,325*	,399*	,327*	,497*	,431*	1						
		,000	,000	,000	,000	,000	,000							
	ME-P	0,092	0,091	0,023	,145*	,173*	,166*	,404*	1					
		0,112	0,114	0,696	0,012	0,003	0,004	0						
Laissez Faire Leader	Laissez Faire	-0,08	-,156*	-0,1	-0,03	-,159*	-,138*	0,08	,328*	1				
		0,148	0,007	0,076	0,577	0,006	0,016	0,15	0					
Organizational Agility	Competence	,334*	,259*	,343*	,322*	,254*	,315*	,253*	,135*	-,118*	1			
		,000	,000	,000	,000	,000	,000	,000	0,019	0,04				
	Flexibility	,298*	,180*	,260*	,209*	,229*	,206*	,165*	,130*	-0,049	,536*	1		
		,000	0,002	,000	,000	,000	,000	0	0,024	0,395	,000			
	Responsive-ness	,409*	,251*	,334*	,285*	,252*	,347*	,251*	,151*	-,117*	,552*	,486*	1	
		,000	,000	,000	,000	,000	,000	,000	0,009	0,043	,000	,000		
	Speed	,300*	,249*	,310*	,303*	,294*	,269*	,239*	,243*	-0,057	,558*	,510*	,548*	1
		,000	,000	,000	,000	,000	,000	,000	,000	0,327	,000	,000	,000	

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level(2-tailed).

CONCLUSION

In today's world, technology companies, especially, in developed countries are working hard to become a company with organizational agility which is one of the production strategies in today's manufacturing enterprises (Nagel & Bhargava, 1994; Nath et al., 2008; Sukati et al., 2012). Organizational agility is becoming an essential element in eliminating the environmental uncertainties of the supply chain, especially when supply chain management is critical (Sahin et al., 2017:338). The concept of organizational agility emerged after manual production, mass production and lean production, and has been seen by researchers as the top development of the thought of production management and is a critical approach to manufacturing operations (Hormozi, 2001). Today's leaders launch strategic offensives to out-innovate and out-maneuver rivals and secure sustainable competitive advantage (Yozgat and Şahin, 2013). Managers and owners of today's enterprises are aware of the need to be agile to meet customer needs and demands. Therefore, our research about "Organizational Agility", which is an important topic in the literature, and a new leadership style in industry 4.0 "Agile Leadership" that can achieve this may provide significant contributions literature. In particular, it is important to determine the effective and agile leadership type that will provide organizational agility in technopark firms where change and technology are very fast.

FUTURE RESEARCH

Change has been described as one of the few variables in this life. With the Industry 4.0 digital era in enabling more rapid data collection and communication than ever before, the speed of leaders' decision making and change has been accelerated. Attempts to manage and adapt these changes within a reactive organizational system may fail miserably, with autocratic leadership styles. Organizational agility which can be defined as a proactive organizational system, including all departments of an enterprise being agility, can be achieved by contemporary leadership styles such as transformational leadership and transactional leadership even agility leadership which may be the modern leadership style in future. It is held that contemporary leaders who develop past-future connections with their followers may be in a privileged position to navigate such changes. A type of evolved contemporary leadership, termed agile leadership, described precisely this quality. The present research sought to determine how organizational agility exists within a science park organization, how it is described, and the dimensions of o it, and what the relationship between multiple leadership styles and organizational agility. These objectives have been met and addressed in this research.

Evidence of organizational agility was found in this study. As this is one of the first researches in which such empirical findings have been published, an invitation is extended to the scholarly community to explore the subject more in future. Arguably, a deeper research on 4.0 industry will be an inherently positive one, especially by using artificial intelligence. This study has presented the relationship between organizational agility and contemporary leadership, but a new construct of organizational agility leadership, and its' presumed organizational impacts will be studied on. It also offers a further evolution in the way in which we observe business dynamics, that being from an agility perspective. In this context, another suggestion is therefore extended to the academy to more this exploration in service of agile leader development and organizational agility and well-being.

Like other common companies, techno science companies, can be called as industry 4.0 firms, also need leaders who will direct the employees, adapt and motivate them to the fast changing environment. These kinds of leaders are to adapt to the competition by starting organizational change and innovation with their abilities. These leaders can be called as "agile leaders." Agile leadership can be stated ***leadership 5.0***. So who are agile leaders? And what do agile leaders do? Bittner (2018) partly answer this question answer of which is given in additional reading below.

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KEY TERMS AND DEFINITIONS

Agile Leadership: It is a postmodern leadership style that provides organizational agility in technopark firms where change and technology are very fast and leadership style in Industry 5.0.

Agility: It is the capability of a firm, particularly in production department, to adapt the changes in market environment.

Competence: It is the ability of using the other three abilities (Responsiveness, Flexibility, and Speed) of organizational agility.

Flexibility: Flexibility can be stated that a business adaptation its own structure and resources to change, to increase its market share, or to create new product and technology.

Organizational Agility: It is about reaction and adaptation to changes which driven by customers, competitors and technology. Being agile organizationally, not only in enterprise's production department but in other departments as well.

Responsiveness: It is the ability of a firm to respond to technological and environmental changes and customer demands on the right time and right place.

Speed: Speed, which can be explained as the ability of a business to deliver the product or service effectively and in short time, is quite important for a business in aspect of innovation abilities, improving a new knowledge against change

Technopark: It is a kind of science park, where technology is very intense, that creates technology by itself and one of the most important components in Industry 4.0.

APPENDIX

Agile Leaders

I've had this ongoing discussion with a few of my colleagues who says that the term "agile leader" is an oxymoron - that the ideal organization is a bunch of Scrum Teams and not much else. Even in an ideal world, I disagree, and here's why in a nutshell: I've never seen, and have not even heard of, an organization that was successful in their pursuit of agility who did not have a strong leader guiding the vision for what the organization can become, motivating people to achieve that vision, nurturing the pursuit of that vision, and protecting, when necessary, the people who want that vision from the people who don't. The reason for this is simple, and is as old as civilization. As Nicolo Machiavelli observed, "It must be considered that there is nothing more difficult to carry out nor more doubtful of success nor more dangerous to handle than to initiate a new order of things; for the reformer has enemies in all those who profit by the old order, and only lukewarm defenders in all those who would profit by the new order; this lukewarmness arising partly from the incredulity of mankind who does not truly believe in anything new until they actually have experience of it."

As intellectually compelling and self-evident we would like the advantages of agile to be, the truth is that there are people who benefit from the old system, and they didn't get to where they are because they are not astute and influential. They are not simply going to resign their current advantages because someone proposes a superior system; you have to expect that they are going to fight to maintain the status quo.

What Agile Leaders Do?

Agile Leaders focus on three things: (1) they create and nurture a culture in which experimentation and learning are embraced; (2) they collaborate with employees (at all levels in the organization) to find common values to create a greater goal for the company and the teams; and (3) they create an organizational structure that reinforces and rewards the other two dimensions.

Agile Leadership's Focus

Goals

Providing guiding vision for shared goal setting is, in my opinion, the most important focus area, and the one that survives even after the organization and culture are largely self-managing and self-sustaining. The goals they inspire others to contribute to and make their own are strategic, and are generally customer or market focused. By strategic, I mean bold and audacious; both aspirational and inspirational. To providing contrasting comparison, think about the motivational difference between the goal of *landing on the moon and returning, by the end of the decade* with a more prosaic goal of *improving profitability by 25%*; no one is going to tell their grandchildren that they helped improve investor returns.

These motivational goals that leaders help us to identify have some common characteristics: the are motivating and inspiring, but they also are uncertain; they force us to stretch, to do things we have never done before. That's why agility is so important; if we knew how to reach those goals, we should just develop a plan and march to it. Leaders help their employees to persist in the pursuit of their shared goals and values when times get rough and old behaviors want to take over.

Organization

The basic agile team structure is very simple; if we use Scrum as an example, there are only three roles: the Product Owner, the Development Team, and the Scrum Master. But not everything an organization does is done by an agile team; agility is needed whenever we are dealing with complexity, but not everything is complex. If you were running a company that makes paint, research and development would need agility, but the paint factory itself might be better suited to using lean processes; unless you're doing a lot of small-batch custom manufacturing, a predictive continuous flow process is probably better than planning production as a series of Sprints.

The point is that, unless you are a small software start-up, there will always be things outside the scope of what agile teams do, even if they are only as mundane as payroll, accounting, tax compliance, legal, and investor relations. The role of management is to design, monitor, and correct this system to make sure that the organization achieves its goals. Even product development companies need to do more than simply developing the product.

Where agile leadership comes into play in the management context is that they need to make sure that the different parts of the organization, with different operating models, don't destroy each other. Put more positively, agile leaders need to help the organization optimize for flexibility and continuous improvement, making sure that improving customer outcomes always comes first, and that the other parts of the organization support this mission. But the other things need to get done, too.

Agile leaders also help teams progress in their maturity. Agility is not binary, and there are predictable stages that teams go through as they improve their ability to learn and improve. Leaders create a supportive environment in which teams can progress, they provide coaches and exposure to peers who can help the teams learn, and they commit themselves to improving their own abilities in parallel.

Culture

The most important thing agile leaders do is to foster a culture that supports empiricism and learning, and that is constantly seeking better customer outcomes and better ways of achieving those outcomes. The challenge for leaders is that they can't dictate the culture; they can only create the right conditions for it to emerge. Some of my colleagues like to use a "gardener" metaphor: if you've ever had a garden, you know that you can't *make* anything grow. You can create the right conditions with the right amount of water (but not too much), and enough sun (but not too much). You can remove other plants that might compete with the ones you want to grow, and you can protect the plants from predation.

You can't control all factors, however, and an organization's culture emerges only partly as an expression of its leaders' aspirations; most of it comes from the people in the organization, how they treat each other and work together. Culture is the non-copyable *je ne sais quoi* that makes your organization unique. But while leaders can't control and dictate this culture, they can encourage it and cause it to flourish by the examples they set and the behaviors that they model.

Agile Leaders Are the Key to Scaling Agility

Agile leaders play an important, even essential, role in scaling agility in an organization. While agile teams can *fly under the radar* so long as their scope remains small, the larger the scope and scale of agility, the more agile teams need supportive leaders to help them to frame the right goals, to make the organization work in support of agility and not against it, and to evolve the culture to embrace and reward learning, rather than merely tolerating it. What organizations who are struggling to scale their agility are most often missing is strong, supportive agile leadership that helps them to build strong, cohesive agile teams. Agile leadership and high-performing teams work in a kind of feedback loop: weakness in one weakens all, while strong leadership reinforces and strengthens strong teams, and vice versa.

Chapter 8
The Role of Strategic Sourcing in Global Supply Chain Competitiveness

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ABSTRACT

A global supply chain is a core element for an organization's competitiveness. Its success relies on the synchronization of relations, activities, and agreements in order to be flexible, agile, high quality, and cost effective for customers. Strategic sourcing emerges as an important factor to support and integrate the suppliers into the supply chain intelligently. This chapter aims to provide the understanding of how strategic sourcing can contribute to improving a firm's global supply chain competitiveness. In order to do so, it explores the elements to be considered while developing the strategic sourcing: the sourcing process cycle, internal and external relations, sourcing risks, global sourcing application, and supplier development.

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INTRODUCTION

Competitive priorities urge organizations to seek continuous change. The rise of customer expectations and patterns, new entrants, information speed and technological evolution drive organizations to move forward even faster, expand domestic frontiers and engage in worldwide competition in terms of cost, quality and availability of products and services. As markets continuously change, it has also been a challenge to established business models and prior opportunistic behavior to achieve a mindset change. Organizations rethink operations, locations, logistics and how they have been contracting and establishing their relations with the supplier base.

Global supply chain design is a core element for organizations' competitiveness. Its success relies on the synchronization of relations, activities and agreements in order to be flexible, agile, high quality and cost effective for customers. In fact, global supply chain competitiveness can be achieved if there is an efficient supply chain flow of materials, information and services, clear governance control and communication methods, flexibility and agility to satisfy demand or respond to specification changes, plus alignment with members' performance (Verma and Seth, 2008). It is a tremendous challenge for practitioners.

Strategic sourcing is key for successful global supply chain management. As the core challenge of supply chain management is the removal of barriers between the organization and its suppliers and customers in order to maintain customer service excellence, financial position improvement, and operational costs optimization, strategic sourcing emerges as an important factor to support and integrate the suppliers into the supply chain intelligently. It promotes cross-functional, intra- and inter-organizational integration (Chen et al., 2004) considering short- and long-term orientation. Precisely, a purchasing team needs to ensure proper use of funds and resources while defining the correct supply source of the business to achieve forecasted results. Additionally, it is expected that purchasing executives will assimilate market innovations, extend market communication and ensure supplier reliability.

This chapter aims at understanding how strategic sourcing can contribute to improving a firm's global supply chain competitiveness. For this purpose, the remainder of the chapter will be structured as follows: the initial section presents a brief discussion of what strategic sourcing is, and the internal and external relations. It is based on a framework that explores how corporate and strategic purchasing alignment contribute to the sophistication and reliability of the strategic sourcing function, and the different internal and external stakeholders. Through the alignment between organization and purchasing strategies, the organization can define paths for developing suppliers, identifying and mitigating supply risks, introducing innovation and cost optimization for the entire supply chain. Furthermore, it presents the core elements of the sourcing process cycle, the different types of buyer-supplier relations and their applicability.

Next, there is discussion of global sourcing and the supplier development process, strategies and constraints on local and global sourcing. This chapter is concluded by discussing sourcing risks and mitigation strategies. Risks are the all possible events or decisions that could hinder or impact the organization's objectives or the supply chain flow.

The analysis offered by this study contributes to advancement of the current literature on the theme. Strategic sourcing can offer a unique contribution to operations and supply chain competitiveness by creating opportunities for establishing better intra and interfirm relations.

WHAT IS STRATEGIC SOURCING?

Purchasing has been shifting its tactical role to a core element for strategy and competitiveness of organizations (Palraj et al., 2006; Tassabehji and Moorhouse, 2008). Sourcing strategy expands the intention of defining how one organization is supposed to buy in a manner that supports a firms' profitability (Anderson & Katz, 1998). It means that purchasing activities extend the traditional, tactical procurement function to a more complex, sophisticated role, which includes the definition of long-term plans, alignment of purchasing and organizations' competitive priorities, and support for global operations and supply chain strategies.

To support global supply chain competitiveness, strategic sourcing includes internal and external relations, and the definition of different deployment strategies for different sourcing methods. Moreover, it comprises definition of the type of buyer-supplier relations the organization would like to address, and how to do so, the range, quality and diversity of suppliers, the methodology of searching for players and ensuring business sustainability.

Traditional strategic sourcing methods urge executives to apply commoditization and competition. On one hand, it is worth commoditizing goods and services using a matrix, and trying to standardize complex negotiation (Vitasek, 2018) in order to reduce procurement variability and try to increment procurement governance. Additionally, purchasing executive performance is often measured by purchasing price variance, which leads to a myopic focus on "price" only. It causes severe constraints on perceiving the overall value of the business, and it blinds practitioners from identifying unknown costs and introducing changes and innovations within the supply chain. The intent is to present an inverse approach. Instead of putting buyers and suppliers in a conflicting arena with ambiguous goals, it is proposed that, by using the correct tools, organizations can really share mutual gains.

In this sense, buyers and suppliers can co-create value by developing joint business, sharing experience and knowledge, and, through the minimization of uncertainty, they are able to optimize costs, increase speed and flexibility to the benefit of the entire supply chain.

Strategic sourcing can be transactional, relational or investment-based. In this sense, based on Vitasek's study (2016), strategic sourcing can be categorized into seven models as follows:

1. **Basic Provider:** Transactional-based approach based on a little differentiation level of what is offered in the market. Due to the high availability level of suppliers, it is easy to switch from one to another. Bidding is quite common in this model.
2. **Approved Provider:** In this transactional-based category, it is also easy to substitute one supplier by another if the supplier does not attend sufficiently well. However, a pre-qualification is needed to conform to certain specifications, standards or requirements.
3. **Preferred Provider:** This is a relational-based approach. The difference between the preferred provider and other two transactional-based models is due to the buyer's perception of value of the business relation with a specific supplier. This model tends to present collaborative relations. This kind of supplier is also pre-qualified but presents evidence of value-added business and a favorable level of performance.
4. **Performance-Based:** This relational-based approach extends the ability of a supplier to satisfy not only purchasing needs, but also its willingness and capability to introduce improvements to the business. This kind of model requires robust controls and collaboration due to the significant level of synergies between both parties.
5. **Vested business:** The third relational-based approach consists of a model with a high level of collaboration, because both organizations are concerned about the other's success. Usually it is applicable to business that demands a high level of shared innovation, which would not be developed by itself.
6. **Shared Services:** This invested-based approach extends that of the preferred provider, but it is an internal supplier (instead of an external actor), and this unit charges internal customers per transaction or on a current cost basis (a subsidiary that centralizes a specific operation to attend an entire manufacturing network, for example).

7. **Equity Partnership:** A high level invested-based approach is when an organization does not have sufficient capabilities to conduct outsourcing or does not intend to do so. Equity partnership can be represented by potential joint ventures among organizations, or by buying a supplier.

Upon alignment between corporate and purchasing strategy, the organization can identify the best model to fit each situation.

However, strategic sourcing is not static. It also encompasses make-or-buy decisions in a continuum continuous cycle. The decision to outsource or revert to outsourcing decisions (by purchasing from the local market or reshoring, i.e. bringing previously offshored items or services back to the country of origin), or to extend cost appraisal, consider consumer preference, availability and quality of raw material or skilled labor, access to domestic markets, and government incentives. For example, some time ago, there was a trend to outsource products and services from India and China, due to low labor costs. Recently, due to American government incentives, U.S. firms have been re-evaluating this strategy and reshoring several businesses (The Economist, 2012). Nevertheless, beyond the government incentives, there is a significant part of American customers that prefer to purchase items produced in the U.S. instead of imported ones.

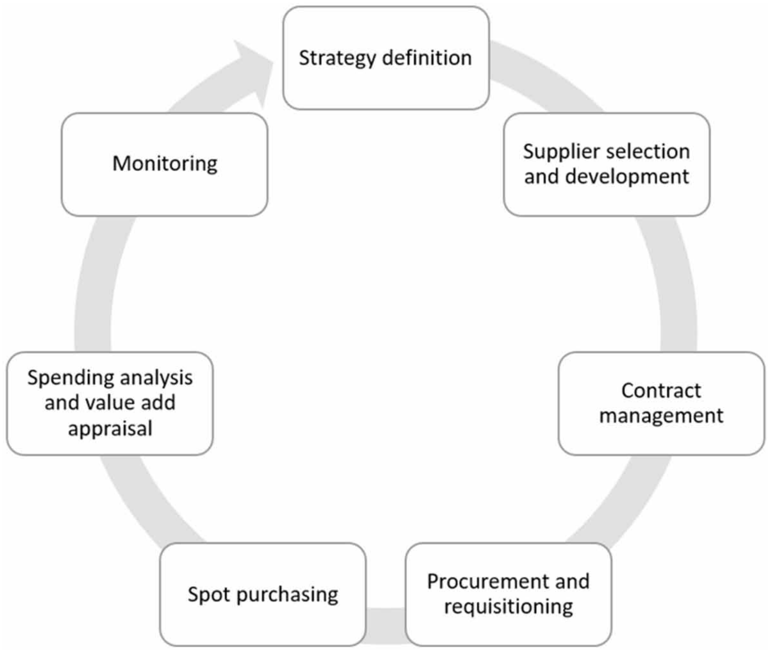
In this case, strategic sourcing has to consider the identification of the impact on an organization of the alternatives, estimate costs and benefits, perform decision analysis and monitor decisions (Presley et al., 2016). Moreover, internal and external impacts are also subject to analysis and surveillance.

SOURCING LIFECYCLE

The sourcing lifecycle refers to definition of all activities in sourcing strategy, demand identification, supplier selection, negotiation and contracts, payment, value and spending analysis, and performance monitoring. It requires several decisions linking internal and external stakeholders, as can be seen in Figure 1.

The starting point is the definition of sourcing strategies and competitive priorities in procurement activities. Furthermore, based on category management, the level of complexity of the market, demand, value and risks, purchasing executives develop suppliers and relations. It includes matching organizations and suppliers' business plans and appraisal of market competitiveness. This approach will lead executives to conduct negotiations, contract management and setting up actions for business in a short and long-term perspective. Further organization is able to conduct daily routines of requisitioning and procurement of parts and services, based on established agreements. Procurement executives will also address policies for spot purchases.

Figure 1. Sourcing lifecycle
Source: Devised by the author



Moreover, the sourcing lifecycle extends the traditional procurement-to-pay (P2P) process by observing and evaluating expenditure and compliance analysis, as well as the value proposition of the business. Finally, the sourcing lifecycle includes monitoring actions in place, issues in contracts, SLA and procurement performance, and outcomes.

In this sense, the main discussion for strategic sourcing to boost global supply chain competitiveness should consider:

- **Strategic Alignment:** What is the short- and long-term orientation? Is this acquisition forecasted in the company's budget? Is this acquisition in line with the organization's competitive priorities?
- **Order Requirements and Specifications:** Are the specifications clear enough for identifying the correct supply source? Who can better detail what it is intended to acquire (and offer technical support during the negotiation process)?
- **Supplier Development:** What kind of suppliers are needed for the demand planned? Is the current supplier base capable and reliable to meet the needs? Is any new entrant interesting for the business? Are the current outsourcing

strategies feasible for the competitiveness? What kind of new technologies or improvements can the suppliers address to improve supply chain competitiveness?

- **Purchasing Decision and Intelligence:** Does the purchasing team have enough market knowledge to take the best decision for the organization? Is the procurement intelligence data available to support the decision-making process?
- **Contract or Purchase Order Generation:** Are all clauses or requirements clear to the supplier? Is there an agreed SLA for aligning the service level expectations to the orders/business?
- **Records and Evaluation:** Is there control of all data requested for monitoring suppliers' performance and purchasing outcomes? How can the value added by suppliers' initiatives and negotiations be measured?

INTERNAL AND EXTERNAL RELATIONS

The future and success of global supply chain competitiveness will depend on how practitioners leverage internal and external relations, how they diagnose issues and business opportunities, and how they can match both sides' needs and interests. In fact, purchasing executives bridge internal and external demands.

It means that purchasing executives must have a clear comprehension of the organization's demands (short- and long-term strategies) and match them to a dynamic, complex supply market environment. Moreover, an organization has to closely manage suppliers, third parties and internal stakeholders in order to develop capabilities that will lead the firm and its supply chain players to achieve superior results and business sustainability. This topic explores the internal and external relations approach to support the strategic sourcing role.

Internal Alignment and Relations

One of the critical points for the success of organizations is the alignment between corporate and purchasing strategies and defining how it will be deployed within the strategic sourcing action plan. As Narasimhan and Das (2001) argue: "*Purchasing integration however requires more than the adoption of key purchasing practices […]. Unlike strategic purchasing practices that typically have an external orientation and are aimed at the supply base, purchasing integration is an internally focused initiative, aimed at aligning strategic purchasing practices with the firm's competitive priorities*."

Internal and external factors must be exploited during the formulation of corporate and purchasing strategies. Internal factors comprise an organization's strengths, weaknesses, and organization capabilities, assets, technology and resources to satisfy current and future market needs (Watts et al., 1995). External factors are market environment, uncertainty, supplier base capability to achieve an organization's quality goals, fulfil delivery, flexibility and cost needs, deal with newcomers, the innovation level and speed, etc.

As shown in Figure 2, the strategy development and applicability process comprise four blocks:

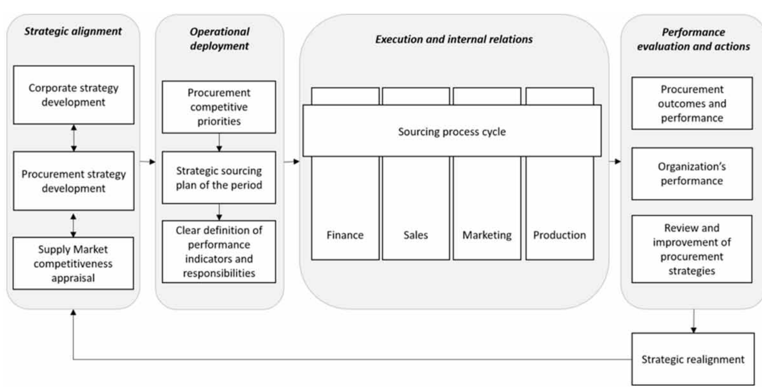
Strategic Alignment

For strategic purchasing to exist, corporate and functional strategies must be consistent. (Carr and Smelzer, 1999, p. 200).

Purchasing has a significant impact on business performance in terms of cost, quality, reputation and reliability. Purchasing strategy must be aligned with corporate strategy and be aware of the organization's competitive priorities in order to extend the organization's scope of demand and match with market capacity and opportunities, ensuring that the suppliers are able to conform to the organization's quality standards, achieve cost competitiveness and the level of delivery flexibility needed, or, if it would be more feasible and viable to produce internally due to supply market constraints.

It is also important to highlight that purchasing executives must be aware about changes in corporate strategy that could impact the organization's reputation or

Figure 2. Purchasing strategy deployment
Source: Devised by the author



contracts. For example, if one organization decided to stop a production line or close a plant in a specific country, it would be necessary to assess the existing supply contracts and evaluate the impact on the local business environment.

On the other hand, purchasing strategy may contribute to corporate strategy through appraisal of the supply market competitiveness. By exploring how supplier base dynamics evolve, an organization can also define new products or services, new business opportunities, new partnerships, joint-ventures, etc.

Operational Deployment

As strategies are aligned, the next step is the internal deployment of decisions to be made in real time to ensure competitiveness. At this point, purchasing is able to comprehend and set up competitive priorities and targets. In order to fulfill the potential of the purchasing role, capabilities, practices and the action plan must be evaluated in order to co-ordinate how value can be developed for all the businesses and the supply chain members.

For example, if corporate strategy is based on the highest quality of its products as a competitive business priority, strategic sourcing must deploy it by developing world class suppliers, high quality standards, and, in some cases, there is a cost trade-off in this strategy. Strategic sourcing has to comprise which products or services are highly impacted by this strategy; which suppliers are critical for achieving superior quality results, and what kind of negotiations and agreements would be necessary to ensure the quality reliability of the final product. This is a crucial phase for creating a clear strategic sourcing action plan, which includes how it will be measured (indicators), and what the deployment responsibilities are.

Besides, it is necessary to conduct a self-assessment of the purchasing team's capabilities versus the organizational and purchasing strategy. What enabling technologies are needed? Is the team skilled or trained enough to fulfill purchasing strategies and goals? Is the process and structure adequate to achieve the organization's goals? What kind of structural changes are needed, how long does it take to implement these, and how much it will cost the organization?

Clear definition of procurement roles is crucial for the governance and quality assurance of the business. Instead of allowing a lot of employees to procure, the idea of concentrating this role on a group of professionals leads to a continuous learning process, optimum use of resources, performance monitoring, process governance and mitigation of corruption.

Procurement specialists can exploit their capabilities and expertise to evaluate the past business, the issues and mistakes occurred in previous negotiations, and look forward to changes to achieve a more sustainable outcome. This predictive exercise can reinforce internal and external orientation of strategy deployment among supply chain members. It supports the comprehension of results of decisions and a variety of new forms of conducting the business.

Market competitiveness continuously changes, and purchasing organization has to follow and adopt continuous improvement as well. It is worth diagnosing how the purchasing structure is established and performs to design a clear action plan. This approach aids practitioners to comprehend the limits of the procurement contribution in the short-term and develop restructuring of what is required to provide for the organization's long-term needs. The diagnosis also offers support in identifying potential weaknesses and strengths in internal and external relations.

Execution and Interdepartmental Relations

An organization is a complex entity, and to ensure that resources are allocated properly, that there is the right quality, delivery on time and in a reliable manner, organization interaction and collaboration are needed. Purchasing practitioners need to translate business objectives and communicate them to the functional areas and stakeholders. In this sense, strategic sourcing demands collective work and relations that are fundamental for supply chain success. It means that executives co-ordinate several steps to link their role with other functional areas, aligning individual goals and responsibilities to achieve corporate results. By doing so, the sourcing process cycle embraces other organizational departments and a common comprehension of their contribution to the firm's success. It is important not to ignore that several other people in other areas are part of the sourcing process, like such as in finance, marketing, sales, engineering, production etc. Executives must comprehend the links, the "start" and "finish" of each process, interdepartmental specificities, and, in some cases, rules and norms.

By working together, people can discuss different perspectives, solve problems, identify new opportunities, share ideas. Geographical distance is not an issue in this case. Due to technological advances, no matter where people are located, executives can easily contact each other and attend virtual global meetings to keep team integration.

However, it is not an easy task. It is common for conflicts to arise between supply and sales, marketing and production, purchasing and operations, etc. Usually these are caused by conflict on individual performance metrics, resistance to perceive other departments' constraints and difficulties to align priorities among the team. The purchasing team has to conquer the trust of other functional areas within the organization and demonstrate how integration of functional roles can contribute toward the organization's success.

Thus, top managers can urge for internal integration by developing cross-functional teams, committees, shared plans and indicators. Furthermore, in order to avoid pitfalls, it is important to care about compliance, knowledge, transparency and foster diversity in the decision-making process. Purchasing must develop and focus its practices and initiatives in a way that it can be part of the business planning process (Narasinham and Das, 2001), discuss investments in assets, external suppliers, and how they can contribute to competitive advantage in the supply chain.

Performance Evaluation and Actions

Performance evaluation refers to a systematic way to assess targets, control the evolution of activities and continuously improve sourcing and supply chain practices and strategies. It is essential to support a better decision-making process, communication, feedback and comprehend the contribution of current activities to develop the firm's competitiveness (Moncza et al., 2016).

Performance evaluation supports the focus on priority areas, provides data for devising better action plans, support improvement of internal and external relations, and demonstrate a possible lack of resources needed to fulfill the organization's goals (Johnson and Flynn, 2015)

As shown in Figure 1, procurement strategy deployment is a cyclical process. It can be noticed that corporate and purchasing strategic alignment contribute to the sophistication and reliability of the strategic sourcing function. By devising a robust plan and developing adequate purchasing practices, an organization's capacity to acquire resources grows, resulting in better purchasing performance (Rodrigues Escobar, 2017) and the possibility of continuously reviewing current practices, learn from failures, and reshape strategies. In fact, the outcomes of procurement performance and lessons learned are the inputs for adjusting purchasing and corporate strategy continuously.

Based on this, procurement strategy deployment has three different ramifications:

1. **Planning-to-Strategy (P2S):** The core of strategic sourcing, it comprises the allocation of resources to define and implement strategies to conduct category negotiations and business relations.
2. **Source-to-Contract (S2C):** Based on individual needs, procurement operations address the correct contract method to be adopted.
3. **Procurement-to-Pay (P2P):** Encompasses all steps from the identification of the need to delivery and supplier payment.

External Relations

Regarding external relations, usually purchasing owns the organization's "front door keys". It means that purchasing executives have an important role in relation to the market: they represent the organization's strategy and behavior. In this sense, they bear the responsibility to comprehend to what extent external stakeholders influence the global supply chain: suppliers, third parties (brokers, agents, freight forwarders, outside business units, local and global government agencies, etc.).

Previous studies reinforce the fact that the greater the strategic sourcing in a supply chain, the better the performance and relations between buyers and suppliers. It also requires a substantial effort to co-ordinate activities, have a good communication flow, ethics and goodwill behavior among all the organizations. The goal is to achieve buyer and supplier satisfaction with the agreements and business. It could minimize uncertainty and supply risks. However, in the face of changes in supplier or buyer behavior, satisfaction will decrease, and the relation will immediately be impacted. Consequently, several business agreements could be impacted as well. Issues such as refusal to accept new orders, to pay bills, unilateral price changes without notice, and illegal actions could have a severe impact on business and the bilateral relation. In order to avoid such pitfalls, goodwill behavior includes willingness to share information and provide fair opportunities for all the parties.

But what kind of relation will be established between buyers and suppliers? There are several approaches to consider while defining the relation that will best fit the business.

Williamson (2008) proposes that sourcing continuity has value, and he identifies three different approaches to conducting this continuity: the first is the muscular approach, assuming the larger or the powerful side of the relation deals in a peremptory way. It means that powerful executives tend to use the supplier when it is worth their while, and the next moment, they can simply disregard them. It is a trap for those who do not comprehend the value of long-term relations. Furthermore, Williamson presents a benign approach. In order to deal with uncertainty, promote continuity and mutual gains, collaborative behavior is necessary. Finally, as time goes by, and organizations become aware that sourcing is complex, they start adopting a credible approach through the development of shared actions to mitigate potential risks and align opinions on market forecasts.

The relations are based on power dependence (Scott and Westbrook, 1991; Handfield and Bechtel, 2002), supplier attractiveness (Olsen & Ellram, 1997), value and level of complexity of the product or service ordered (Kraljic, 1983).

As shown in Table 1, there are four basic types of relations that can be developed:

Table 1. Types of supplier relations

Relation	Supply base	Methods
Arm's length	Multiple sourcing	Competitive tendering and spot buying
Co-operative	Fewer suppliers	Negotiation and preferred supplier with framework agreements
Collaborative	Possible single source	Open book
Partnership	Single sourcing	Joint working towards continuous improvement

Source: Emmett and Crocker (2006, p. 98)

Depending on the nature of the purchase and the market environment, buyers define what kind of agreement and relation will be more feasible and viable for the business. Initially, Carr and Pearson (1999, p.500) stated: "*Adversarial buyer–supplier relationships are characterized by purchase transactions where the items are low in priority and there are numerous sources of supply. However, a cooperative buyer–supplier relationship is more desirable for the buying firm when purchased items are high in priority and the sources of supply are limited to a few suppliers. A cooperative relationship refers to the process of working together, over an extended period of time, for the benefit of both firms*".

It can be perceived that the arm's length relation is associated with an adversarial buyer-supplier relation, and businesses counting on fewer suppliers tend to be more co-operative or collaborative. But this is not absolutely true… The relation approach also needs to consider relational posture (the mutual attitude of buyers and suppliers) and relation intensity (the strength and number of transactions between both firms). According to Kim and Choi (2015), arm's length relations tend to lead to a focus on short-term gains (adversarial relation). However, depending on the relational intensity, the buyer can increase control over the supplier, synchronize expectations and reduce uncertainty. Consequently, both can share additional information and knowledge, and, instead of competing against each other, they can start consolidating a more intense relation and expand their business opportunities.

On the other hand, organizations can have close ties and a co-operative relation, when all the organizations are closely linked in their operations, are responsive and maintain specialized interfaces. They keep a high level of purposive interdependence, and there is a willingness to co-operate and share information. Nevertheless, when organizations have close, but adversarial, ties, all the organizations are forced to be closely linked, due to their high level of dependence. However, there is an adversarial, power-seeking competitive environment, and, consequently, opportunism prevails over mutual business benefits.

Power dependence has a particular influence on the buyer-supplier relation. It refers to situations where one party does not have control over all the conditions required to achieve a desired performance (Handfield and Bechter, 2002). In situations where there are few suppliers or only one owns the technology or knowledge necessary to attend a customer requirement, suppliers can exploit the market and offer fewer choices to customers to be competitive. Long-term relations and agreements, and the possibility of foreseeing future benefits to be derived from the contract can avoid opportunistic behavior in this sense. It depends on a willingness not to use their power against the customer.

In this sense, the construction of trustful relations seems to be worthwhile. According to Handfield and Bechter (2002, p. 372) "[…] *investments in supplier relationships are established to minimize risk, involving activities traditionally considered the exclusive domain of the other party. Such investments lead to significant increases in the quality and duration of relationships, which further increase the likelihood that parties may be willing to make greater investments in future transactions.*"

It is worth highlighting that buyer-supplier relations are subject to conflicts of interests, and individual behavior can substantially impact business outcomes. Thus, purchasing executives must be aware of the different behavior their teams and suppliers can adopt, the disadvantages and advantages of each style, define and align with team members the proper behavior they are expected to practice in each situation. It requires training, discussion and profound market analysis.

Important barriers can emerge during the development of buyer-supplier relations. Actors can be reluctant to change a supplier, to share information due to confidentiality constraints, lack of trust, or the supplier may not be so interested in expanding the business.

GLOBAL SOURCING AND SUPPLIER DEVELOPMENT

Globalization opens up an avenue of opportunities for diversification of suppliers, more business, a greater range of products and services, technology, and cost optimization. It offers several advantages, such as lower costs due to lower labor rates, access to items or services that are not available in the local market, continuity of supply, subsidies or advantages exchange rate variations. However, it demands extra effort on the part of the purchasing executives to investigate the capability of suppliers, if the business is sustainable, secure and ethical. Consequently, it demands that the organization continuously audit suppliers, visiting plants/units abroad, and studying local culture, legal issues, tariffs and duties, as well as the level of commitment.

Global sourcing is a major challenge and a trend for organizations. It refers to the integration and co-ordination of materials, processes, practices, specifications, and suppliers across international locations (Trent and Monczka, 2003), with internal and external stakeholders (Gelderman and Semeijn, 2006), and it has several drivers depending on the organization' competitive priorities (Quintens et al., 2006).

For example, an organization may intend to improve product development. Thus, cost advantage, better delivery performance, high quality products, unique products, access to better technology, can be fundamental in searching for suppliers abroad. At organizational level, global sourcing strategy may intend to ensure organizational flexibility or integration with worldwide activities and dynamics. At supply chain level, organizations may take advantage of existing logistics systems or broaden supplier base diversification. In short, despite the drivers and motivations a firm can have, usually the prominent goals are cost reduction, access to resources and access to sales markets (Jia et al., 2017).

It can be perceived that organizations' sourcing strategies gradually evolve toward a global approach. It normally starts with domestic purchasing, and organizations begin to search internationally for sourcing to optimize costs. Next, international sourcing becomes part of the organization strategy, and it is perceived as an element to support the organization's endeavor to become more competitive. Furthermore, organizations realize the need to create a global strategy to co-ordinate sourcing supplies, and, finally, the global sourcing integration includes other functional groups.

The decision to outsource requires continuous appraisal of its competitiveness, feasibility and viability. For example, contracts previously signed with low-cost suppliers in other countries, may become uncompetitive as time goes by due to changes in global market dynamics, new entrants, new local and political strategies, increased supply risks, longer lead times, currency fluctuations, etc.

Awareness of market changes and continuous organization strategy alignment implies definition of the best supplier and contracting modes. External politics, macroeconomic conditions and cultural distance are important elements to evaluate. Executives may count on support of from third parties, such as brokers and experts, trading companies, networking and business units located abroad. Additionally, executives have to comprehend infrastructure constraints and possible logistics alternatives to address correct calculation of freight, lead time, hidden risks and costs. It is important to emphasize that each country, each region has it owns specificities and requirements for a careful, profound appraisal. It is important to develop purchasing intelligence politics to collect data from different, reliable sources, and develop a data analysis methodology.

A global sourcing strategy expands international purchasing. It comprises the development of global business units to support the co-ordination and monitoring of the sourcing initiatives. In more sophisticated, bigger organizations, it includes the possibility of acquiring functional groups abroad to support and manage global procurement. In this sense, global sourcing decision-making can be centralized at the headquarters and international purchasing offices, or global commodity managers can be in charge of reporting, managing and co-ordinating procurement activities in their regions. In more mature purchasing structures, part of the decision-making can be also decentralized (in line with corporate and purchasing strategy). Units or structures located abroad can be more sensitive to market and political changes that can influence the business, and, consequently, can be an important input source for procurement intelligence.

Global strategic sourcing can explore regional trade agreements as a possibility to identify opportunities in emerging economic markets, such as NAFTA (recently renegotiated), the European Union, Mercosur, China's Trade Agreement, etc. Reports such as the Global Competitiveness Report and the Global Risk Report provided by the World Economic Forum (https://www.weforum.org/reports) offer interesting data and information for developing a global sourcing strategy.

There are important trade-offs for realizing global sourcing. The longer the distance between the firm and its supplier base, the higher the inventory required to support the global supply chain. It has cost implications and flexibility constraints to attend customer changes. As a matter of fact, long lead times also require investments in inventories, working capital and risk management. A robust global sourcing strategy can balance low-cost suppliers in other countries and local ones, or search for alternatives close to customers, depending on the business developed.

SOURCING RISK MANGEMENT

Strategic sourcing offers several benefits: based on purchasing strategy, buyers can define whether or not to negotiate with several suppliers (multiple sourcing) in order to identify the best alternative for a need or if the business will be conducted through a partnership with a reduced number of suppliers (single source). Both strategies present trade-offs as well. The main challenge of the purchasing executives is to identify the potential risks and mitigate them (Berger and Zeng, 2006). Risks are all the possible events or decisions that could hinder or impact the organization's objectives or the supply chain flow. It can comprise situations that will cause inability of the firm to fulfill customer requirements, or even endanger customers' lives (Zsidin, 2003), such as supplier failures, variations in demand, unplanned resources, product changes, environmental disasters, etc.

The sourcing process may be subject to several different types of risks as presented in Table 2.

All potential risks must be evaluated by the purchasing team and other organization members in order to verify the probability of an impact occurring, whether it be a supply disruption, a cost increase or any other impact on the organization and its supply chain. The risk assessment evaluates the likelihood of an event occurring based on risk exposure. Furthermore, an appraisal is made of the tangible and intangible consequences, if the event indeed occurred (Harland et al., 2003). It extends an intra-organizational approach to an inter-organizational supply chain approach.

However, risks can be shared among the members of a supply chain. The team needs to co-ordinate how supply chain members communicate and adopt risk management tools to mitigate them throughout the supply chain (Moncza et al., 2016). The risk sharing varies depending on the level of the relation established between the buyers and suppliers, defined in formal agreements, which can include long-term commitments, responsibilities and how to handle sensitive information in case of an unforeseen event.

Thus, despite the possible geographic distance and cultural differences, there are several compliance and ethical issues that need to be monitored, such as modern

Table 2. Sourcing risks

Sourcing risks	Examples
Supply capacity risk	Supply disruption, demand fluctuation, bullwhip effect
Sustainability risk	Fluctuations in interest rates, quota restrictions, unanticipated resource requirements, carbon footprint - high levels of CO_2 emissions during the sourcing activity
Business risk	Supplier's financial stability
Quality risk	Quality decrease due to suppliers' failures, rework, recall
Technology or specification changes	Product design changes, supplier's lack of technology to conform to specifications, supply disruption, cost and lead time increase
Disasters	Outside control event, supply disruption
Process and control risk	Inefficient supply teams in the organizations
Reputational risk	Illegal or unethical activities conducted by third parties or suppliers that can exert immediate impacts on firms and the supply chain's reputation.
Demand risk	Variations in demand, uncertainties in demand market

Source: Adapted from Christopher et al. (2011) and Zsidisin et al. (2000)

slavery, human rights abuses, sustainability responsibilities, corruption and fraud, etc. Whenever possible, due diligence checks on the suppliers' sites may be undertaken in order to monitor and encourage suppliers to have ethical practices, and identify possible risks, mitigating them as soon as possible.

CONCLUSION

Strategic sourcing and supply chain management go hand in hand. The role of supply chain management is to remove barriers between organizations and its suppliers' suppliers in order to attend customer needs, achieve profitability and competitive advantage. In this chapter, it is sought to understand how strategic sourcing can contribute to the enhancement of the firm's global supply chain competitiveness.

Global supply chain responsiveness demands knowledge of customer requirements, the organizations' and partners' capabilities, and the translation of organizations needs to suppliers. As a matter of fact, by establishing clear relations and contracting, the variety of suppliers can concentrate their role on business development.

Strategic sourcing can offer unique contributions to supply chain competitiveness, creating opportunities for establishing better intra- and inter-firm relations. Through the alignment between organization and purchasing strategies, an organization can define paths for developing suppliers, identifying and mitigating supply risks, introducing innovation, and optimizing costs for the entire supply chain. By reducing supplier uncertainties, strategic sourcing can optimize supply chain effectiveness and efficiency.

The contribution made by strategic sourcing operations is seen as fundamental for a business to succeed. Meaningful integration and involvement of purchasing executives on core strategic decisions can reveal opportunities to resize and have a beneficial impact on organizations and supply chain performance. While much focus of supply chain management has been on external relations, improving and aligning internal functions demonstrate a step ahead to enhance competitiveness. By transposing internal conflicts, an organization can leverage interests and realize a more profitable and sustainable business in every situation.

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KEY TERMS AND DEFINITIONS

SLA (Service Level Agreement): Is an agreement between a suppler and a buyer that defines the level of service standards expected and the obligations of the supplier. It also presents the performance elements of the order placed, which can be compared with other suppliers and serve as an indicator of the efficiency and effectiveness of the business.

Spot Purchasing: Sporadic or unplanned orders originated in unexpected circumstances.

Chapter 9
Managing Electronic Supply Chains

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ABSTRACT

During the early 2000s, the advent of internet and e-communication enabled organizations to be more responsive and cater to their customers' needs in a better way. Over the last few years, integrated technologies and ERP systems has allowed organizations to gain market share and establish themselves as e-commerce players. This has been achieved through better synchronization, business realignment, and operational flexibility. The rapid development in fields of information technology has transformed old partnerships between suppliers, buyers, and service providers into a more collaborative business process where information and knowledge sharing is a key success parameter. Through enhanced IT capabilities, SMEs can cooperate to form a network and promote their joint capacities to acquire a complex project and integrate resources for a better planning and execution. In this chapter, the author seeks to highlight the importance for e-SCM to be implemented and adopted, current status of adoption through case studies, benefits of e-SCM as strategy and challenges plaguing adoption of e-SCM.

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INTRODUCTION

Over the last few years, technological development in the field of information technology has revolutionized every industry and disrupted business models and strategies. It has paved the way for new opportunities and bringing competitive advantage to organizations. Supply chain management is a key component of all industries in the business world and developments in IT has transformed the way a typical supply chain operates. Technological advancements in supply chain are critical, allowing improvements and enhanced efficiencies and quality in material, information and financial flows. A supply chain is deliberated as a network of organizations and/or individuals involving material, information and financial flows. The flows can be described as: Product flow- movement of goods from supplier to customers and/or returns. Information flow involves transmission of information about the order, product, customer feedback, order tracking and delivery status etc. Financial flow- consists of payment terms and conditions, mode of payment, ownership – lease titles etc. The efficiency and speed of these flows determine the quality of customer service and total costs associated (Stevens, 1989). Over the past decades, the advances in supply chain technologies has brought about a tighter integration and better efficiency in the flows through business realignments and improved operational flexibilities (shown in Figure 1 (b)) (O Cattaneo, 2010). Other

Figure 1a. Showing traditional supply chain flows and flows in a re-engineered supply chain

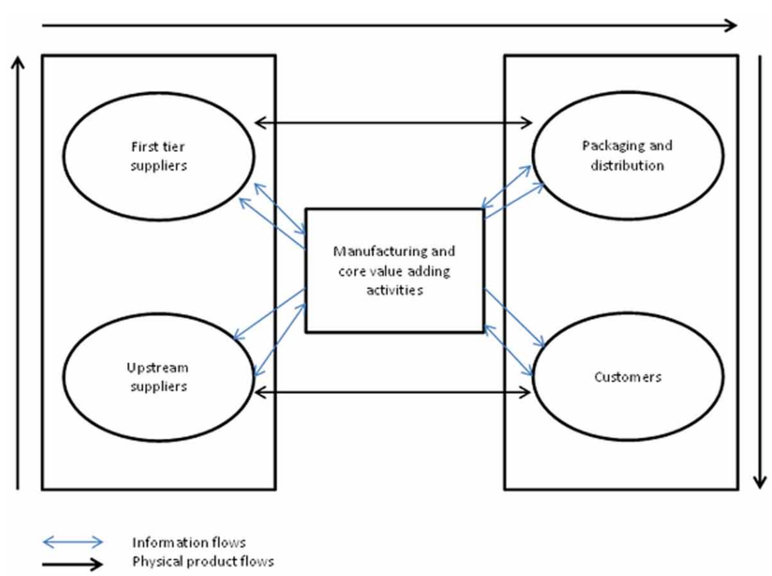


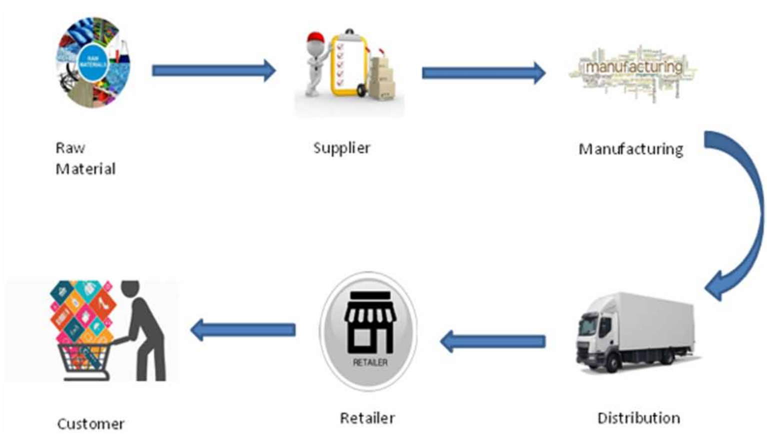
Figure 1b.

contributing factors to the advances in supply chain include uncertain and volatile business environment, increased competition, and advanced communication.

Traditional model of supply chain involved movement of goods through the procurement of raw materials into the manufacturing/processing unit, involving warehousing, storage and distribution of goods to physical retail outlets including shops and distributors before reaching the final customer. The respective information and material flows are shown in Figure 1 (a). This involved a comparatively larger investment in terms of resources and had innate drawbacks like poor visibility across supply chain of information, production bottlenecks, bull whip effects leading to increased cost of operations, handling and storage etc. A traditional supply chain (Figure 2) is represented in the flow below.

Not a long time ago, the idea of electronic supply chain was limited to a handful of tech-savvy companies dealing with digital products such as e-books, movie titles, music etc. With the advent of technologies in supply chain, e-commerce disrupted the traditional supply chain in the sense of how a supply chain is designed, operated and maintained. This promoted other industries and organizations to venture into the sale and distribution of other physical goods without the additional burden of transportation, warehousing and production costs. E-commerce enabled the traditional

Figure 2. A traditional supply chain



supply chain to be moved to either a completely online platform (for example Amazon or a dual-channel platform including physical retail and internet-based supply channel (Dell/Walmart) ((Atiq W. Siddiqui, 2015). Supply chain and e-commerce have been researched elaborately in the past with several studies highlighting the progress and issues plaguing these two domains. A study highlighted the impact of internet on the businesses and its economic outcome (RJ Kauffman, 2001) while another study focused on the security and privacy of doing business online (Udo, 2001). An extension of e-commerce, mobile commerce (m-commerce), was studied to determine recent developments in the field (PE Kourouthanassis, 2012). Other technologies in supply chain such as RFID and tags have also been assessed and reviewed (A Sarac, 2010).

E-SCM is, therefore, presented as the effective utilization of internet and related technologies along with business process re-engineering that helps in delivering the desired goods and managing all three flows of supply chain effectively from the supplier to the customer in a most efficient and organized way. A key challenge facing e-SCM adoption and implementation is the dispersed marketplaces and characteristic demands and how to optimize and integrate efficiently these using advanced IT (Li, 2005). E-business approach could be used to resolve this issue by planning and executing front and back-end value add processes using web based applications. E-supply chain when incorporated with e-business approach enables increased value addition, process agility and visibility, efficiency and customer service (Li, 2005). E-SCM has been defined as the collaborative use of technology to enhance business processes and improve speed, efficiency, real-time data and control and customer satisfaction. It also affects the management policies, culture, key performance metrics, and organizational structures (Norris, 2000). Understanding this, the objective of e-SCM is to incorporate all activities across and within organizations, integrate and coordinate with other players to create competitive advantage and ensure customer satisfaction and retention.

FACTORS LEADING TO INTRODUCTION OF E-SUPPLY CHAIN MANAGEMENT

Several factors in literature can be found that have been enablers for introduction of electronic supply chain management. These factors have risen due to changing business needs and environment for different organizations (Ross, Competing through supply chain management, 1998) and backed the alteration of SCM to e-SCM.

1. The urgent need of organizations to reduce costs and offer improvements, however incremental, both upstream (suppliers) and downstream (customers).

2. Rising bargaining and purchasing power of customers, thereby, introducing the need for agility, speed and flexibility on part of organizations to cater to customer demands
3. The need to offer continuous improvement in service levels and product/service quality along with a need for reduction in holding inventory, manufacturing costs and distribution.
4. E-SCM also plays a critical role in smooth transition from in-house production to outsourced demand fulfilment, especially for non-core functions and products, outsourced to specialists.
5. Opening up of newer markets and unexplored regions leading to a huge spurt in demand and thus pressurizing organizations to modernize their supply chains through new techniques like e-commerce, m-commerce and dual channel supply chains.
6. Suppliers, service providers and organizations used to work in isolated silos without much interaction and information sharing leading to ill-planned projects and difficult execution of projects. The advent of internet and new age technologies has brought all the players together through networks, leading to transparency and clear visibility across the supply chain, adding competitive edge and ability to compete for market share.

PRINCIPLES OF E-SUPPLY CHAIN MANAGEMENT

The principles of a traditional supply chain overlap with those applicable to e-supply chain. Supply chain professionals often find themselves stuck between the need to address customer service and demands at high service and quality level and the business goals of organization for growth, higher net returns and profitability. These principles help strengthen the importance of treating the entire supply chain as whole and not isolated pods and also stress the significance of coordinating SC activities like planning, sourcing, assembly, delivery and information sharing to address the overall aim of customer satisfaction and retention. The 7 principles of supply chain management have been described below (DL Anderson, 1997).

Adapting the Supply Chain to Customer Needs

Customers need and demands are always at the forefront for business people and supply chain professionals. Customer are classified into different groups using a technique known as ABC analysis to achieve segmentation of customer groups based on sales volume and/or profitability. Anderson et al, segmented the customers on the basis of service needs i.e. sales needs, and order fulfilment needs. An example of this segmentation is the speed and/or price of shipping for customer order fulfilment. Many e-commerce players like Amazon and Alibaba offer free shipping and quicker delivery options like 1-day discounted delivery depending upon their customer service segmentation.

Customizing Your Logistics Network

Logistics design is mostly driven by customer needs and order fulfilment policy. Depending upon the customer need segmentation, the logistics network may need to be customized to service different customer sections.

Demand Planning Across Supply Chain

Demand data is a critical input in supply chain planning and production decisions. It helps to control and/or eliminate bull whip effect, thus reducing the need for unnecessary stock holding. Demand data must be shared across the supply chain to keep the information flow transparent. Results from an interesting study (M Waller, 2011) state that if the demand forecast is made using SKU/customer level data, using historic order data presents an accurate forecast than collecting point of sale (POS) data from retail points. However, if the demand forecasting is done based on store level requirements, using POS data is more accurate than using historical order data.

Outsourcing Decisions

Outsourcing is basically described as getting activities completed by third party suppliers that were originally completed in-house. This principle categorically states that an outsourcing decision should be strategically made and an organization should never outsource its core competency. Outsourcing could help reduce costs drastically if implemented effectively. Some of the to-avoid practices for outsourcing decisions include: don’t outsource your core competency, difficult-to-imitate activities. Secondly, draft clear and precise contracts detailing the activity and/or service required. Thirdly, selecting vendors based on lowest price is not always the best option. Revenue streams may be generated or enhanced through other channels but saving money with a bad outsourcing decision could prove even more costly. Lastly, there should be an exit strategy in place with back-up suppliers available to avoid sole outsourcing.

Differentiating Products

Dell is world-renowned for its supply chain practice of keeping its computer systems and peripherals in a 'broken' down state and assemble them only when a customer places an order. This has helped Dell to increase product variety and ability to differentiate. However, standardization is another practice that sometimes enables organizations to drive costs down. This can be attained by formulating or developing products with packaging and labelling that complies with multiple country legislations. This kind of standardization enables the organization to cater to multiple markets and drastic cost reduction through economies of scale.

The Confluence of IT and Decision Making

Before adopting a new IT framework in supply chain, business process reengineering needs to be done to address and identify the key loopholes or deficiencies of the system and align your technology needs accordingly. A majority of success parameters for an IT project in supply chain are aligned to process management and reengineering, organizational alignment and management commitment, development of a work and resource plan, understanding of strategic goals and vision etc. It is also dependent upon the availability, accuracy and adaptability of data, education and training, implementation and site related issues etc. Implementation of an IT project or ERP system effectively changes how an organization operates and it is heavily reliant upon proper planning and project management (Dojo, 2016).

E-SUPPLY CHAIN INTEGRATION

Integration across supply chain is a key exercise that can ensure that all components of the supply chain are seamlessly working as an extended enterprise. Integration in a supply chain infers that the supply chain operations i.e. product design, raw materials supply, production, packaging, delivery, customer relationship management etc. are all harmonized with the virtual enterprise leading to coordination throughout the supply chain. SC legacy and operational systems are merged into a networked business domain connected together through internet and other software and communication packages to ensure holistic integration as a virtual entity. This integration is more aligned to information systems integration rather than the physical, organizational integration. The integration can be classified into three different segments depending upon the need of the organization – Synchronization oriented, cooperation oriented and innovation oriented integration (Li, 2005).

1. **Co-Operation Oriented Integration:** Cooperation oriented integration is aligned towards using transparent information for not only reducing costs and other KPIs but also towards improving coordination activities and decision support mechanism. Partners across the supply chain can utilize the available information to make joint decisions regarding product planning, demand forecasting, pricing decisions, new product development etc. This enables joint effort, thereby reducing costs and increased profits through economy of scales in production through cooperative planning and forecasting.
2. **Synchronization Oriented Integration:** This kind of integration enables real-time information sharing amongst all partners including retail sales data, stock levels, finished goods in stock and in transit, etc. Such real time data enables all partners to design operational planning to avoid demand distortion, increase responsiveness and agility and reduced lead time and quicker turnaround to customers.
3. **Innovation Oriented Integration:** Internet options in ERP system may enable direct ordering and automatically processed orders for delivery without any intermediaries. This enables development of a completely new business model and higher levels of supply chain visibility. Catalogue management and interactive web access including web chats using bots allow customers to configure products as per their requirements. It also facilitates implementation of mass customization through dynamic production planning based on real time data.

MANAGING E-SUPPLY CHAINS AS VIRTUAL ENTERPRISE

Adopting an e-business approach to supply chain enables some of its activities to be performed virtually operating as a virtual enterprise where virtual environment enables opportunities to improve flexibility, efficiency and cost reduction. Virtual enterprise has been defined by several researchers in the past. It has been defined as a number of independent vendors, customers, and competitors developing a network through technology to meet the customer demand and cost targets (WH Davidow, 1992). From a supply chain perspective, it may be used to illustrate the supply chain of a product in a dynamic environment within a network of companies engaged in SC activities by coordinating their internal systems throughout the SC (Muller, 1996). Essential characteristics of the virtual enterprise are listed below.

1. Collaboration between associates based on their core competencies and skills
2. Aim to achieve business objectives collaboratively not feasible by a single enterprise

3. A temporary partnership and network development based on individual business opportunities and disbanding the collaboration after the business opportunity is achieved
4. Sharing of information, cost, risks and technology
5. Virtual enterprises engage in transactions online in the web world, therefore, there is no physical inventory, warehouse, assets or resources
6. All partners in a VE are legally independent and geographically spread out.
7. Almost entirely based on virtual technologies like internet, cloud, mobile and ICT

Over the last few years, various researchers have discussed agility and responsiveness as key success parameters for organizations to deal with volatile business environment and changing/fluctuating demands (P. Swafford, 2006), (Barnes, 2011), (A. Gunasekaran, 2008), (A. Samdantsoodol, 2012). All the research suggests that virtual enterprise is capable of generating quicker turnaround times with better responsiveness and agile functions to be more market sensitive and sync demand-supply paradigm. The operation of a virtual enterprise treats supply chain activities with an e-business approach, thereby, vertically integrating the whole supply chain. Workflows are then managed by web based applications enhancing the visibility of the entire process and aggregating and synchronizing the operational processes based on customer requirements. Similarly, from a customer perspective, it makes accessing the product catalogue easier, thereby quicker access for ordering and exchanging information. Web-based activities in manufacturing can be used to monitor production process and design. Process and quality charts may be accessed in real-time giving immediate control to process misses and manage shutdown times. Further advancements in the field of virtual adaptation include a network that leverages SMAC (social media, mobile, analytics and cloud functions) technologies and also enables machine-machine conversations increasing end-to-end visibility. More applications include telemetry wherein manufacturing units are digitally updating their performance in terms of maintenance, inventory, bottlenecks etc. Analytics is playing a major role in digitalisation of supply chain. Manufacturers are able to monitor fulfilment and transportation of goods along with supply and demand planning. Analytics is also being utilised to assess the product lifecycle with aim of improving the product design and engineering. For any organization, it is vital to move to a digital platform to manage and operate their supply chain. If not applied to the complete SC, few important areas to focus for virtualization of supply chain may be forecast accuracy, on-shelf fulfilment and capability assessment (Blanchard, 2014). Virtual enterprise performs many an important function for any organization. This may include customer interaction, resource configuration and management, process co-ordination and knowledge sharing. Virtual enterprise functions may ease the burden of customer interactions, including feedback and product returns, virtual marketing, online retail, distribution, and payment, customer relationship management, and virtual customer interaction i.e. through chats, messaging services etc. Virtual sourcing is another key task that may be executed by sourcing potential vendors/partners, online consultations and negotiations and contracting (Li, 2005).

APPROACHES FOR E-SUPPLY CHAIN MANAGEMENT

e-Supply chain management with the use of technologies like internet, cloud and mobile communications has enabled business organizations to be lean, agile and responsive while simultaneously be able to develop new business models. There are a few approaches that are beneficial to organizations with the implementation of e-SCM.

1. **E-Procurement:** Procurement is described as the activity involved in obtaining certain products and/or services from suppliers through purchasing and inbound logistics. E-Procurement is the electronic version of these activities wherein goods/services are procured virtually through electronic order processing and enhanced options for buyers like EDI messaging etc. This helps to eliminate paper trail, thereby, reducing administrative costs and increases operational efficiencies. These e-procurement activities are supported by enterprise resource planning systems and internet. All the process including sourcing vendors, requesting for quotes (RfQ/RfP), and raising purchase orders are done online, therefore, helping in enhanced quality through an expanded supplier base. It works equally efficiently for a supplier as the supplier can upload their catalogues (e-catalogues) on the shared ERP network, through which the buyers can shortlist products and place orders into a cart online. It may also be used to highlight the current stock levels with vendors that in turn, act as a guide for buyers to plan their in-house production activities accordingly.
2. **E-Portal:** An e-supply chain portal is a vital approach for e-SCM through business process re-engineering. Such a portal can act as a knowledge platform for collaborators and provide transactional data to suppliers and customers. An application of e-SCM portal has been observed in the US department of Defense which has helped integrate diverse sectors and organizations (S. Boyson, 2003). E-Procurement can also be managed through the e-SCM portal by providing necessary tools to everyone involved and allows higher returns with lesser degree of effort.

3. **Co-Ordinated Planning, Production and Decision Making:** Suppliers and customers can work in conjunction depending upon the stage of production i.e. WIP, sale, instock levels etc. Coordinated supply can be attained through vendor managed inventory (VMI). VMI in coordination with internet and virtual enterprise capabilities can be implemented at a quicker pace with real time demand and production data. A pre-set trigger can be added to order goods automatically based on a minimum threshold stock and thus depend on a mutually agreed replenishment cycle. Coordinated product development is another important decision crucial for reducing time-to-market, improving quality and reducing costs. Knowledge sharing and information access from a common platform in a network of suppliers can enable identification of a new product/technology/process. Web-enabled designing procedure in real time like CAD and engineering helps in a consensus on a common design among different partners. This may help in reduced design time, consistency of data, better product quality and lower lifecycle costs.

BENEFITS OF ADOPTING E-SCM

Investments in e-business approach and e-supply chains is increasingly being seen as a strategic investment because it has enabled firms to better manage supply chains through reduced costs and increased responsiveness (E. Brynjolfsson, 2000). In the above sections, numerous benefits have been highlighted, some of which are listed below:

- Increased information visibility and sharing
- Better real time forecasts
- Improved collaboration
- Faster to-market time and responsiveness
- Real time interaction and communication
- Drastic cost reduction
- Improved net returns
- Improved customer relationship management and customer retention
- Increased customer service levels and satisfaction

Therefore, it can be summed that e-SCM help to enhance end-to-end visibility across the entire supply chain along with improved customer responsiveness, high customer satisfaction and service, increased agility and flexibility in view of a volatile business environment, and more effective marketing (Horvath, 2001). This thus changes the traditional standpoint of supply chain and transforms it into a more customer centric and IT enabled supply chain which is more characteristic of the e-supply chain (Figure 3) (The Logistics Institute-Asia, 2001)

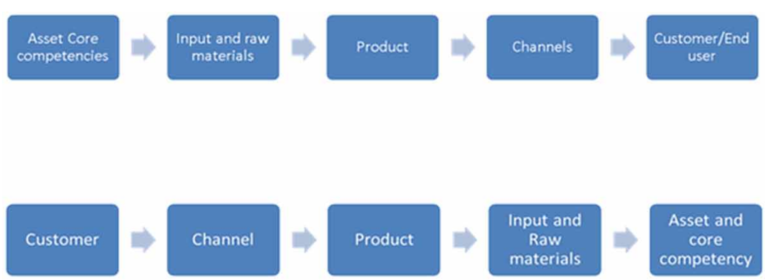
Thus, as the supply chains continue to partner and transform using internet technologies, new competitive edge is being gained through e-collaboration, online marketplace, networked planning, operations management and customer order fulfilment and connecting all channel information, transactions and decision making (Ross, 2003).

CHALLENGES TO ADOPTING E-SCM

As highlighted in earlier sections, e-SCM offers a plethora of opportunities and benefits to organizations open to adopting it as a business model and strategy. However, there are a few constraints and challenges that pose a hurdle for any organization to smoothly implement and incorporate e-SCM. These challenges are summed up as below.

1. It may be challenging for organizations, suppliers and partners to effectively integrate all the information and material flow within the demand and supply processes.
2. Implementation and adoption of software and ERP modules to enable e-SCM poses cultural and technical concerns as well (D. C. Chou, 2004). There may be security and privacy issues for some of the business partners in revealing their business and product/process oriented data. There may be technical challenges in terms of safety and security of the web-based network against external threats as viruses and hacking attempts.

Figure 3. E-supply chain starting with a customer centric approach



3. Sometimes, over reliance on technology and its perceived ability to solve any problem may prove to be a hindrance. Clarity of vision and the necessary change in business processes is important before adopting supply chain virtualisation. It involves a carefully planned strategy which should be in tune with technology adoption and implementation.
4. It is critical to identify the key partners, the exact number of collaborators, and the consensus on technology or system to be implemented (Lidija Pulevska-Ivanovska, 2013)
5. Addressing, identifying and establishing a clear e-SCM roadmap and spending adequate time and resources on strategy development.

Use Cases/ Successful e-SCM Implementation Cases

This section highlights the successful use cases from global multinational organizations that have implemented e-SCM as a business model and strategy to achieve market share and competitive edge, along with reduced costs and higher returns.

Dell had always been at the forefront of a dual channel supply chain model wherein its key products from the diverse portfolio were maintained and stocked as individual components and only assembled when a customer order was received. The build-to-order strategy was successfully implemented using internet based integrated virtual organization and online sales strategy. At the time of implementation of strategy, Dell observed 58% revenue increases and 82% profit increase (Cyberlibris, 1999). This was achieved through information sharing about customer orders and forecasts and exchange of inventory for information.

Cisco is a worldwide leader in networking technologies used in communication devices and platforms. To maintain this global position, Cisco has to continuously be connected with numerous partners and effectively manage its supply chain. To sustain as a market leader, Cisco implemented an integrated supply chain network to bring together its suppliers, distributors, resellers and manufacturers and manage them as a single virtual entity. With this adaptation, Cisco's revenues continuously rose while simultaneously improving customer relationship and gross margins. Approx. 90% of its orders are processed seamlessly online and 98% of their components manufactured at partner facilities. This has been achieved through extensive forecast and planning information being shared with partners throughout the supply chain (Cisco, 2012).

Wal-Mart is one of the largest retailers worldwide having a huge network (>11,000 stores) of large-scale retail department stores and warehouses. Walmart has revenues of over USD 500 billion and is the world's largest corporation in terms of revenue according to Fortune Global 500 list in 2018 (Global, 2018). It has over 2 million employees with highest sales per square foot, inventory turnover and operating profit

(Lidija Pulevska-Ivanovska, 2013). This has been achieved through effective supply chain management, with integrated suppliers, manufacturing facilities, warehousing and distribution. Walmart is able to accurately forecast demand, predict inventory, optimize transport routes, and manage customer service and responsive logistics through its technological advancements and network design. This has led to lower overall costs, reduced inventory holding costs, and competitive pricing.

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KEY TERMS AND DEFINITIONS

E-SCM: It is the effective utilization of internet and business processes that help in delivering goods, services, and information from the supplier to the consumer in an organized and efficient way.

ERP: Is the integrated management of core business processes, often in real-time and mediated by software and technology. ERP is usually referred to as a category of business-management software—typically a suite of integrated applications—that an organization can use to collect, store, manage, and interpret data from these many business activities.

Offshoring: Offshoring refers to obtaining services or products from another country, and is often what news articles are really referring to when they discuss outsourcing. While much offshoring involves outsourcing production to another company it can also refer to simply re-location certain aspects of a business to another country.

Outsourcing: Outsourcing refers to obtaining certain services or products from a third-party company, essentially sourcing something like accounting services or manufacturing of a certain input to another company.

RfQ (Request for Quotation): Is a standard business process whose purpose is to invite suppliers into a bidding process to bid on specific products or services. RfQ generally means the same thing as call for bids (CfB) and invitation for bid (IfB).

VMI: Vendor-managed inventory is an inventory management system in which a supplier assumes responsibility for the timely replenishment of a customer's stock.

Chapter 10
Policy Designing via System Dynamics

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ABSTRACT

This chapter aims to explain system dynamics approach. System dynamics approach was developed by Jay Forrester from MIT during the 1950s to analyze especially the complex behavior in administration with computer simulation in social sciences. System dynamics is a form of systems approach as a methodology to understand the dynamic behavior of complex systems. The basis of system dynamics is to understand how system structures cause system behavior and system events. System dynamics deals with how things change over time. Almost all are interested in how the past formed the present moment and how today's actions determine the future.

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INTRODUCTION

Tools for learning about complexity must also facilitate the process of systems thinking and policy design. While the virtual world enables controlled experimentation, it does not require us to apply the principles of scientific method. Similarly, defensive routines and groupthink that thwart learning in teams can operate in the learning laboratory just as in the real organization. Effective modeling often requires members of the client team to recognize the limitations of their inquiry skills and address their own defensive behaviors. Managers unaccustomed to disciplined scientific reasoning and an open, trusting environment with learning as its goal will have to build these basic skills before a system dynamics model—or indeed, any model—can prove useful. Developing these skills takes effort and practice.16 The list of successful interventions using system dynamics is growing. Of course there are also failures, as the community of modelers continues to learn and improve the tools and process. Recent successful projects in the business world include strategy design for a highly successful wireless communications startup, leasing strategy for a large automaker, supply chain reengineering in a number of major high-technology firms, a new marketing strategy for a major credit card organization, long-range market forecasts and strategy development for a major commercial aircraft manufacturer, clinical trial and marketing strategies for new pharmaceuticals, models for effective management of large-scale projects in software, civil construction, shipbuilding, aerospace, defense, and commercial product development—and many others(Sterman, 2001: 22).

Jay Forrester initially constructed his first dynamic model upon his meeting with the management of General Electric corporation. Big fluctuations in production, inventory, labor force and profitability were compelling GE management. Despite hard efforts of the management, these fluctuations were mostly associated with external factors. Especially, the fluctuations in the business were related to received orders. Forrester interacted with the management to observe the system operations in other departments. In the first model he developed, he observed that simulations were necessary since the system could not be monitored analytically. He demonstrated that the corporation could experience serious fluctuations due to management policies even when the demand is considered constant with the weekly simulation he ran. Later on, he designed the computer simulation for the same problem. In his later studies, Forrester demonstrated how the feedback control theory could be adapted for complex administration and human systems. He published his initial findings in an article in Harvard Business Review. Later on, he developed this study to write his famous work "Industrial Dynamics" (Lane and Sterman, 2011; Ramage and Shipp, 2009: 100-101).

However, how can one come to understand the whole system? How does policy resistance arise? How can we learn to avoid it, to find the high-leverage policies that can produce sustainable benefit? For many, the solution lies in systems thinking—the ability to see the world as a complex system, in which we understand that "you can't do just one thing" and that "everything is connected to everything else." With a holistic worldview, it is argued, we would be able to learn faster and more effectively, identify the high leverage points in systems, and avoid policy resistance. A systemic perspective would enable us to make decisions consistent with our long-term best interests and the long-term best interests of the system as a whole (Sterman, 2001: 9-10).

SYSTEM DYNAMICS

System dynamics deals with how things change over time. Almost all are interested in how the past formed the present moment and how today's actions determine the future (Forrester, 1995: 16).

System dynamics is designed to model, analyze and improve socio-economic and administrative systems using a feedback perspective. Dynamic structured administrative problems are modeled by mathematical equations and using computer software. Dynamic constructions of model variables are obtained using computer simulations (Forrester 1962; Ford 1999; Sterman 2000; Barlas 2008).

The main principle of system dynamics is that the ongoing accumulation of the complex behavior of organizational and social systems (human, material, financial assets, information, biological and psychological states) is also the result of balancing and empowering feedback mechanisms. (Richardson, 1999).

System dynamics is an interdisciplinary problem-solving methodology that utilizes several significant thinking skills such as dynamic thinking and cause-and-effect thinking. System dynamics is a disciplined collaborative approach that could accelerate learning by combining a multifaceted perspective that provides insight into complex and interactive issues (Richmond 2010, Soderquist and Overakker 2010; Ferencik, 2014).

System dynamics is a method that allows analysts to separate complex social, and behavioral systems into components, to visualize them by reconstructing them as a whole again, and to develop a simulation model (Tang and Vijay, 2001: 3).

There is never one single correct answer in system dynamics. Since system dynamics represents the relationships within the current system, it presents multiple possible approaches that could be applied, instead of providing a single correct answer. Each approach could provide some of the desired result, as well as some unexpected ones. In fact, another significant characteristic of system thinking is to become aware why we preferred a solution over others (Sterman, 2000: 127-133). System dynamics was designed to help managers make decisions similar to other information technologies. The aim of system dynamics studies is to assist decisions by analyzing old policies and designing new ones (Wheeler, 1994: 80).

System dynamics models are not derived statistically from time series data. They are statements related to policies and system structure that guide decisions. Models include admissions made about the system. A model is only as good as the expertise that underlies its formulation. A good computer model is distinguished from a bad one by the accuracy of its reflection of the system it represents. Several other mathematical models are limited due to the nonlinear nature of the real system and the lack of their inclusion of several feedback cycles. On the other hand, system dynamics computer models could reflect real system behavior (Forrester, 1995: 6).

System dynamics is a compilation of tools by which we could understand the structure and dynamics of complex systems. What was meant by complexity is the fact that these systems contain characteristics such as delay, feedback, and a large number of stocks. System dynamics is based on the control theory and modern nonlinear dynamics theory. However, understanding the complex systems requires more than solely mathematical tools. Since complex systems involve human and social systems as well as physical and technical tools, system dynamics is in direct relationship with cognitive and social psychology, economics and other social sciences. Therefore, it could be argued that system dynamics is an interdisciplinary method (Öğüt and Şahit, 2012: 5, Senge, 2002, Sterman, 2000).

The system dynamics model may include either linear or nonlinear, stable or unstable, parameters, or parameters that do not return to their initial state, based on the structure of the system being examined. The main philosophy of system dynamics is to address "socio-economic systems as continuous feedback control systems." The basic concept here is the term "feedback." The dynamic behavior of the system is provided by feedback cycles. Complex systems are a collection of feedback cycles interacting with each other (Erkut, 1983: 16, Campuzano and Mula, 2011).

Forrester (1962) refers to system dynamics as use of models for the exploration of the information-feedback characteristics of managed systems and for the design of developed organizational structures and guiding policies. Forrester defined system dynamics as the integrated expression of systems that form social and economic structures and feedback mechanisms that interact with each other. Coyle (1996) defined system dynamics as a branch of the control theory related to socio-economic systems and the administrative sciences that investigate auditability. Wolstenholme (1990) defined system dynamics as a rigorous qualitative method that describes, explores, and analyzes the processes, information flows, organizational boundaries and strategies of complex systems. This method allows for quantitative simulation modeling and analysis to design system structure and behavior.

The system dynamics approach is a simulation method used to analyze complex, nonlinear, dynamic feedback systems and to design policies to improve the system performance (Radzicki, 2007: 727).

System dynamics deals with the behavior of time-dependent management systems in order to identify and understand system behavior with qualitative and quantitative models. It investigates how system behavior is managed by information feedback and how simulation and optimization could be utilized to design healthy information feedback and control policies (Coyle, 1996: 10).

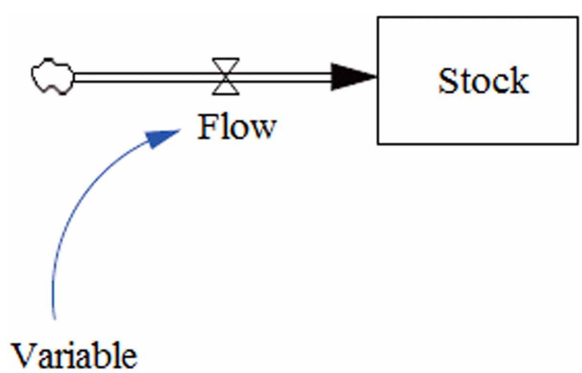
Since its inception, system dynamics has been successfully implemented in the struggle with strategic challenges and in support of strategic processes. Applicability of system dynamics might be limited due to factors such as lack of time, high uncertainty and the inability to access existing databases (Vennix, 1995, Warren, 2005, Herrera, 2014).

Structure of the System Dynamics Model

Forrester created a language called system dynamics to define system behavior. This language consists of four components: stocks, flows, decision functions and information flow. As a result, the only thing we need to define the system is to create these four blocks despite the level of complexity of the system. System dynamics language is presented in Figure 1.

Dynamic analysis deals with time flow. So first, we have to define time. Time could simply be defined as a dimensionless real number. There is a starting point and it continues in the positive direction in the coordinate system. In this case, two different concepts stand out. The first concept is defined as a moment in time and denoted as $\tau = 1, 2, 3, \ldots$ The second concept is the time period and denoted as $t=1.$,

Figure 1. System dynamics language
(Resource: Yamaguchi, 2013)



2., 3,... The unit of time could be expressed in seconds, minutes, hours, weeks, months, years, decades, hundreds of years…, depending on the structure of the examined system. In system dynamics, the two time concepts must be distinguished correctly, because the stocks and flows need to be defined explicitly as τ and *t*. (Yamaguchi, 2013: 23).

The elements that constitute the dynamic system model could be explained in four groups such as stocks, ratios, decision functions and information flow.

Stocks (Levels) and Flows (Ratios)

While the stock could be defined as accumulation, the flow refers to the rate that stock levels change. Stocks could be clearly defined as inventory of raw materials or finished products. Some are less clear, partly because the everyday language does not identify them as stocks. An example is the cash balance generated by the deposit and withdrawal of funds. Stocks are the accumulations within the system. These accumulations could include concepts such as inventory, business volume, number of employees in different qualifications and experiences, and workforce, etc. Stocks are the present values of the variables that are formed by the accumulated difference between the inflow and outflow (Sezen and Günal, 2009: 306-307; Erkut, 1983: 44).

The most important of the four components that form the foundation of system dynamics is the stocks. System could be defined as the combination of stocks. Stock is the sum of objects that exist at a given time τ. If we express stocks with an *x* in a specific time τ, stocks could be expressed with x(τ), when τ is a real number (Yamaguchi, 2013: 23). The stock structure is presented in Figure 2.

A common way utilized to explain the change in stocks is to determine the stock value τ *=1, 2, 3,...* at specific points in time and take into account the amount of change in stocks at the next point in time. The period between τ and $\tau+1$ is called the unit time interval. The unit could be defined as seconds, minutes, hours, days, weeks, months, years as mentioned above. This period of time is defined as τ. τ's are defined starting from point $\tau = 0$ (the point of origin), (1st time interval, 2nd time interval, 3rd time interval, ...).

On the other hand, flow is defined as the increase or decrease in the unit time interval in stocks and denoted by f (*t*). The flow could be defined in each intermittent

Figure 2. Stocks and flow

time period, which is then called the intermittent flow. The flow is related to the amount of time between two points in time (unit time interval), while stocks are defined as the quantity at a certain point in time. In other words, τ is used to define stocks. This corresponds to a point in time. τ is used to define the flows and the t^{th} unit time interval is the time between τ point in time and the next $\tau+1$ point. Any dynamic behavior could be understood functionally with the terms of stocks and rates. Flow is the rate of change in stocks. It refers to the changes in stocks. In the bathtub example, the flow is the water entering the bathtub through the faucet and the water leaving the bathtub via the duct. Births and deaths, revenues and expenses, glucose intake and glucose consumption, and etc. are all examples of flow. In these examples, birth represents the inflow and death represents the outflow (Yamaguchi, 2013, Martin, 1997a, Sterman, 2000, Barlas, 2005b).

As can be seen in Figure 3, the flow is an integral part of stocks. In this context, flow and stock units should overlap physically and qualitatively. We could denote the relation between stocks and flow as follows:

$x(\tau+1) = x(\tau) + f(t)$ τ ve $t = 0, 1, 2, 3,\ldots\ldots$

Table 1 demonstrates distinctions between stocks and flow in different disciplines.

To avoid the notation confusion between τ and t, we need to express these two concepts with one of the two. Since t denotes the time interval between τ and $\tau+1$, the stock amount in t^{th} time interval $x(t)$ could be defined as the stock amounts of τ, which is the beginning point of the time interval, and $\tau+1$, which is the end point of the time interval. Accordingly,

$x(t) = x(\tau)$: Stock at the beginning of the process

Figure 3. Relationship between stocks and flow
(Resource: Yamaguchi, 2013)

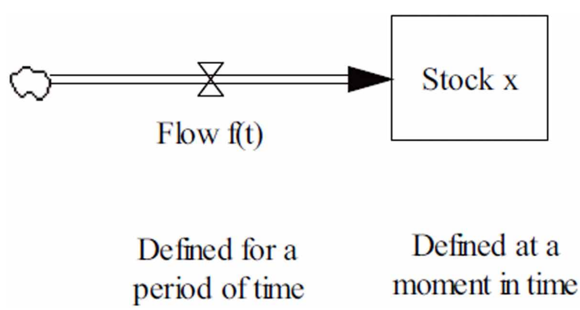


Table 1. Terminology used to distinguish stocks and flow in different disciplines

Field	Stocks	Flows
Mathematics, Physics and Engineering	Integrals, States, State variables and inventories	Derivatives, Rates of change, Flows
Chemistry	Reagents and Reaction products	Reaction rates
Manufacturing	Internal inventories, Inventories	Production rate
Economics	Levels	Ratios
Accounting	Stocks, Balance sheet items	Cash flow
Biology, Psychology, Medicine, Epidemiology	Reservoirs, Prevalence	Prevalence, Mortality rates

(Resource: Sterman, 2000: 198)

or

$x(t) = x(\tau + 1)$: Stock at the end of the process

If the stock at the beginning of the process is used, the stock flow equation (3.1) could be written as follows:

$x(t+1) = x(t) + f(t) \quad t = 0,1,2,3,......$

In the equation above, stock $x(t + 1)$ value is the value at the beginning of $t + 1$ time interval and $f(t)$ is obtained by adding the flow quantity and the stock value.

If the stock equation (3.3) at the end of the process is accepted, the stock flow equation (3.5) could be formulated as follows:

$x(t) = x(t - 1) + f(t) \quad t = 1,2,3,......$

With the above mentioned method, two time concepts (a moment in time and a time interval) are combined.

If $f(t)$ is defined as an intermittent time period such as $t = 1,2,3, ...$, the equation (3.4) is called the difference equation and is expressed as (3.6).

$$x(t) = x(0) + \sum_{i=0}^{t-1} f(i)$$

If the flow is continuous, time units are divided into n sub time intervals and the equation (3.4) could be written as follows (Yamaguchi, 2013: 25-26):

$$x(t) = x\left(t - \frac{1}{n}\right) + \frac{f\left(t - \frac{1}{n}\right)}{n}$$
$$= x(t - \Delta t) + f(t - \Delta t)\Delta t$$

For $\Delta t \to 0$ için $\lim\limits_{\Delta t \to 0} \frac{x(t) - x(t - \Delta t)}{\Delta t} \equiv \frac{dx}{dt}$

$$\frac{\mathrm{dx}}{\mathrm{dt}} = f(t)$$

The above formula is the definition of a differential equation. In cases where flow and stocks are constant, the amount of stock at *t* is found by solving this differential equation.

dx = f (t)dt

$$x(t) = x(0) + \int_0^t f(u)du$$

The general solution of the differential equation is obtained by the above formula. The only difference between continuous and intermittent flows is the integral in continuous flow and the use of total functions in intermittent flow (Yamaguchi, 2013: 27).

Jay Forrester (1962) explained stocks and flows with the metaphor of the water that accumulates in the bathtub and drained from the bathtub. Stocks are the amount of water that accumulates in the bathtub. The amount of water in the bathtub is the difference of the amount of water entering and leaving the bathtub. Stocks are the accumulation of the flows or the integral of flows. Net flow reflects the rate of the change in stocks (Sterman, 2000: 194).

Integral Equation:

$$Stock(t) = \int_{t_0}^{t} [(Inflow(s) - Outflow\ (s)\ ]\mathrm{d}s + Stock\ (t_0)$$

Inflow (s) denotes the value of any flow at any point in time s between the beginning of inflow and the present time t. Similarly, the net stock change rate is derived from this equation and is obtained by subtracting the outflow from inflow as shown below:

Differential Equation:

d(Stocks) / dt = Net Change in Stocks= Inflow (t) – Outflow(t)

SYSTEM DYNAMICS MODELING PROCESS

Forrester's system dynamics modeling steps could be listed as follows (Forrester, 1962: 13):

- Identification of the problem.
- Separation (isolation) of the factors that include the observed symptoms.
- Arriving at new decisions through connecting the decisions to actions and actions to information feedback by following cause and effect information feedback cycles
- Formulation of acceptable and adequate (formal) decision-making policies that define the results of these decisions using existing information flows.
- Construction of the mathematical model for the interactions between decision-making policies, sources of information and system components.
- Formulation of system behavior as defined in the model
- Comparison of the results with all adequate data in the existing system
- Review of the model until it represents the actual system
- Discovery of organizational relationships and policy amendments that could improve system behavior through model redesign
- Obtaining the improved performance by implementing the changes in the actual system as stipulated by the model

DELAYS IN SYSTEM DYNAMICS

An important characteristics of various dynamic systems is the presence of delays that control the system, which are much more difficult to comprehend than it might seem at the first glance. Delays are a characteristic of dynamic systems and affect both material and information flow. The most common ones are exponential and pipeline-type delays (Sezen and Günal, 2009: 326).

Delays are inherent in many administrative processes. For example, it takes time to manufacture a product, to hire or lay out workers, to build a new factory, or to set up services (Kirkwood, 1998: 73).

In principle, there are delays in all flow channels. On the other hand, entering a time delay for each flow results in a quite unnecessarily detailed model, since most of these affect system behavior only very little. When introducing delays into the system, the number of delays could be reduced by two types of shortcuts. First is the case where the system delay is so short that its effect could be ignored. Second, the consecutive delays, which are actually separate, are usually combined and expressed as a single delay (Forrester, 1962: 86).

The delays are actually conversion processes that accept the speed of the inflow and transfer it out at the outflow speed. Delays are a special case of levels. Time delays are indicated as packets in the flow channels. By changing the time relation in the inflow, they create the outflow time relation (Forrester: 1962: 87).

TIME PROCESSING IN SYSTEM DYNAMICS

System dynamics approach usually utilizes the time framing method. The modeler must determine the length of the time frame in advance. One important issue to note here is the accurate selection of the time frame length. If the time frame is extremely long for model behavior, the modeler will miss significant variations, hence, the simulation could provide misleading results. If the time frame is extremely short for model behavior, then model would be examined even at times when a change in the state is not possible, causing excessive collection of data and excessive computer processing time. It is recommended to select a sufficiently short time frame length generally (Sezen, 2009: 320).

CLASSIFICATION OF EQUATIONS

Equations can be divided into three classes. These are level equations, rate equations and auxiliary variable equations.

Level Equations

Levels are the changing contents of system stocks (inventory). Even when there is no existing flow in the system, levels are present (Forrester, 1962: 76). A level equation could be expressed as follows (Sezen and Günal, 2009: 322):

$$Level(Current) = Level(Previous)+dt*(Inflow-Outflow) \quad (3.32)$$

A level equation reflects the accumulation of flow rates that cause increases and decreases in the level content. The new value of the level is calculated by adding to or subtracting from the previous value (Forrester, 1971: 5-7).

Rate Equations

Rate equations define the ratio of flow between the levels of the system. A rate equation is calculated from the existing value of the level. Rates cause changes in levels at the end (Forrester, 1962: 77).

Rate equations demonstrate how the flows in the system are controlled. The rate equation inputs are the system levels and constants, while the output is the control of the flow between the levels (Forrester, 1971: 5-9).

Auxiliary Variable Equations

There are also auxiliary variables in system dynamics models, which are defined as a function of stocks and these are influenced by internal variables and constants and affect the flow variables (Sterman, 2000: 107).

Rate equations would be very complicated if they were only expressed in terms of levels. Rate equations could also be expressed by one or more concepts that are independent of one another. The auxiliary variable equations help to keep the model structure close to the actual system by dividing the rate equations into component equations. As the name implies, the auxiliary variable is insignificant, but only "auxiliary" (Forrester, 1962: 78).

CALCULATION METHODS IN SYSTEM DYNAMICS

In general, the analytical (integral) solution of differential equations is quite difficult or impossible. Usually, numerical approaches are used to obtain solutions (Yamaguchi, 2013: 30). The analytical solution is the real solution. Intermittent approaches are used as an alternative to obtain a solution only when it is difficult to achieve the real solution:

$$x(t) = \sum_{i=0}^{t-1} i \quad (3.33)$$

The calculations made with this approach are unfortunately far from the real value. Two algorithms are proposed to reduce the difference. These are Euler Cauchy and Runge-Kutta methods.

Euler Cauchy (Continuous Flow *dt→0*)

The first algorithm is the reduction of the intermittent periods of the flow: dt →0, thus, the intermittent flows demonstrate a near-continuous flow (Yamaguchi, 2013: 30).

To examine the effect of this method, let us consider the following equations:

Level= dt * InflowRate –dt* OutflowRate

InflowRate= OutflowRate / A whan A is a constant

If we write this as a differential equation;

$$\frac{\mathrm{dL}}{\mathrm{dt}} = \mathrm{I} - \frac{\mathrm{L}}{\mathrm{A}}$$

L and I denotes the level and InflowRate. Euler-Cauchy integral formula for the OutflowRate is as follows:

$$L(n+1) = L(n) + dt\left[I(n).L(n) \,/\, A\right]$$

The Euler-Cauchy numerical integration method is iterative, in this case it utilizes the dT interval (Sezen and Günal, 2009: 325). If we express the Euler method graphically, for each intermittent time period, it is the sum of the areas of the rectangles under the curve. Thinner the rectangles, closer the calculation to the actual result (Yamaguchi, 2013: 30).

$$\frac{dq(t)}{dt} = \lim_{h \to 0} \frac{q(t+h) - q(t)}{h}$$

Although it is a simple method, it contains certain drawbacks. On one hand, to obtain consistent results, dt should be as small as possible. However, as step sizes get smaller, more iterations will be needed. This increases the computation time. On the other hand, it is not possible to decrease step sizes indefinitely, because computer processors start to rounding up these values after a certain value. Thus, another algorithm was proposed (Zeigler, Praehofer and Kim, 2000: 52).

The Euler method is still significant, because more advanced algorithms have been derived using the basic ideas provided by this method. The whole of these algorithms is called the Runge-Kutta method (Pegden, 1995: 436).

Runge-Kutta

All Runge-Kutta methods are the solution algorithms for the differential equation given below:

$$x(t+\Delta t) = x(t) + \Phi \Delta t$$

Where, Φ is the estimator of dx / dt in time interval Δ t. This estimator is a weighted sum of x (t) values in two or more Δ t interval. Although the Runge-Kutta methods are first-degree derivative assessments, they could also be used with *Taylor series* expansion at higher degrees. The derivative term in the Taylor series expansion that corresponds to this algorithm method is called the level of the method. For example, the Euler method we have described above is the Runge-Kutta method from the first degree. Runge-Kutta methods could be developed at higher degrees to obtain higher accuracy results when compared to the Euler method (Pegden, 1995: 436).

A second degree Runge-Kutta algorithm is as follows. Accordingly, the value at the midpoint of dt is taken as f (t) value.

$$x(t+dt) = x(t) + f(t+\frac{dt}{2})dt$$

For instance, for a flow function $f(t) = t^2$ that only depends on time, if we accept the initial stocks as $x_0 = 0$, second degree Runge-Kutta algorithm would be as follows:

$$f(t+\frac{dt}{2}) = t^2 + tdt + \frac{dt^2}{4}$$

And a fourth degree Runge-Kutta algorithm could be written as follows (Yamaguchi, 2013: 31-33):

$$x(t+dt) = x(t) + \frac{f(t) + 4f(t + \frac{dt}{2}) + f(t+dt)}{6} dt$$

See Table 2.

VALIDITY OF SYSTEM DYNAMICS MODELS

The computerized simulation model could be used as a powerful tool to test how policies and structure that generate growth and fluctuations in socio-economic systems interact. For the effective use of the model, it needs to reflect the actual system (Forrester, 1977: 541).

Model validity is as controversial topic as it is significant in all model-based methods, especially in system dynamics. The validity of the results of the model-based study depends on the validity of the model. Nevertheless, there is no single well-agreed definition of model validity and model validation (Barlas, 1996: 183).

Significance of a model is measured by how well it serves its objective. The objective of system dynamics models is to help improve the decisions made. The validity of a model should be decided by its adequacy for the unique objective of the model. If a model serves its purpose, it could be justified and is significant. Thus, validity is an abstract concept separated from the objective. A model that is perfect for an objective might be misleading and useless for another objective (Forrester, 1962: 115).

To investigate model validity, two topics should be discussed. First, we cannot expect a model to be completely valid. A model has been constructed for a specific objective and its validity should be tested for this objective. However, a model

Table 2. Comparison of second and fourth degree Runge-Kutta methods

t	x(t)	Runge-Kutta 2	x(t)	Runge-Kutta 4
0	0	0.25	0	0.33
1	0.25	2.25	0.33	2.33
2	2.5	6.25	2.66	6.33
3	8.75	12.25	9	12.33
4	21	20.25	21.33	20.33
5	41.25	30.25	41.66	30.33
6	71.5		72	

(Resource: Yamaguchi, 2013: 33)

investigated for other objectives might be unreliable. Second, we must realize that positive proof is impossible. The difficulty begins with selecting the validity criteria. There is no absolute proof, but there is a confidence interval for measuring the link between the model, the actual system and the objective. Concurrently, if two different models are measured, there is no assurance that the model that better reflects the measurement findings is the most efficient model (Forrester, 1975: 162).

The simplest model validity form is called the black box validity. In this method, the model is run under well-defined conditions and findings are obtained. The conditions chosen for running the model should be as similar as possible to the actual system. Then, the simulation model should be rendered compatible with the actual system. Thus, the model results should be the same as the actual system results. This is called the black box validity, because the topics of interest are only the system inputs and outputs. The internal structure of the model is not addressed. In this method, we cannot be sure that the model properly describes the operation of the actual system. In order to make sure of this, we must use a method called white box validity. The idea behind white-box validity is to examine the model's operation in more detail and to verify that the simulated system reflects the operation of the actual system appropriately. This validation method examines the programming logic, rather than investigating the result of the model (Fishwick, 2007: 33-21).

The most important aim of the model validity in system dynamics is verification of the model structure; although the validity of the results produced by the model could be assessed, this is only meaningful when the model structure itself is valid. Thus, verification should be conducted with the model structure first and then the behavior of the model should be verified (Barlas, 1994).

Validity could be examined both structurally and behaviorally. Structural validity could be defined as building trust on the fact that the relationships used in a model represent the actual relationships accurately. Barlas (1994) indicated two types of structural tests: 1-Direct Structural Tests and 2-Structural Behavior Tests. Direct building tests provide model validity only by comparing model equations with available information. In the direct structural test, consistency comparisons are made directly on the model without using a simulation. These tests could be empirical and theoretical. The empirical test involves comparing information obtained from the actual system modeled with equations of the model. On the other hand, the theoretical tests include a comparison of model equations with generalized information on the existing system available in the literature. Both tests are important for direct structural validity. Forrester and Senge (1980) gave the examples of structure and parameter validation test, direct end-value test and unit consistency test for direct structural tests. Parameter validation test is to assess the fixed parameters conceptually and numerically using the actual real information. The direct end-value test involves the evaluation of model equations with extreme values, and is a comparison of the result values with the information about what would occur under similar circumstances in real life. Finally, the unit consistency test analyzes the unit consistency of the model equations (Barlas, 1994, Forrester and Senge, 1980, Gökalp, 2012).

The second general category of structural tests is structural behavior tests. These tests assess model validity indirectly by testing certain behavior using behavior patterns created in the model. Indirect structural tests include specialized simulated runs and could provide indirect information about probable errors in model construction. Among these tests, end-value, behavioral sensitivity, limit compliance, and phase-correlation tests could be listed. In a behavioral test for a typical structure, the analyst makes the following proposition: “If the system works in condition K, it should demonstrate behavior D”. If the model works under K conditions and yields similar behavior to the expected behavior, it passes this test. End-value behavior tests are the comparison of behavior created by the model by assigning extreme values to selected parameters and the observed or predicted behavior of the actual system with these extreme values. The behavioral sensitivity test aims to determine the parameters that are sensitive to the model and to test whether the actual system has the same high level of sensitivity for these. On the other hand, the adaptive behavior estimation test could be applied where it is possible to find data about the behavior of the adaptive version of the actual system. The model passes this test if it could produce similar adaptive behavior when simulated with similar adaptations. These two tests are designed to evaluate the validity of the model with the model structure. As a result of these tests, if there is sufficient level of confidence about the model structure, we could begin to apply a number of tests designed to measure how accurate the model reproduces the large behavioral patterns observed in the actual system behavior. Here, It is very important to emphasize the sampling estimate (period, frequency, trend wave size...) instead of point estimation. This is a logical consequence of the fact that system dynamics models have a tendency towards long term politics. Behavioral sample tests could be expressed as the multiple test procedure proposed by Barlas (1985, 1989), the general statistical summary proposed by Sterman (1984), and several behavioral sample tests discussed by Forrester and Senge (1980) (Barlas, 1996, Forrester and Senge 1980, Barlas and Saysel, 1996, Kanar, 1995).

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KEY TERMS AND DEFINITIONS

Decision Functions: States of the policy that determines how to convert available information in stock into a decision.

Delays: A characteristic of dynamic systems and affect both material and information flow.

Flow: It is defined as the increase or decrease in the unit time interval in stocks and denoted by f (*t*).

Information Delay: They are usually caused by the transfer of information and the delay in the process of taking an action after the information is received. Information delays could occur in vertical hierarchical administrations.

Information Flow: Creation, control and distribution of information is the most significant task of business management. It might be difficult to model the information properly in the business process.

Material Delays: In this structure, the material moves forward from the beginning to the end of the pipeline without any change during a period of time, similar to a water running through a pipeline.

Material Flow: It includes stocks and flow rates of physical goods such as raw materials, inventories in the process or finished goods.

Stocks: The present values of the variables that are formed by the accumulated difference between the inflow and outflow.

System Dynamic Language: This language consists of four components: stocks, flows, decision functions, and information flow.

System Dynamics: The basis of system dynamics is to understand how system structures cause system behavior and system events.

Chapter 11
Occupational Health and Safety Hazards in Agriculture:
A Study on the Risks Involved for the Sustainability

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ABSTRACT

Within the agricultural sector, it becomes essential worldwide to analyze the magnitude of OHS problems. However, there is a lack of study in Odisha (India) to assess the prevailing situations. Hence, an attempt was made in this study to explore the issues related to OHS among the farmers of Odisha in India. There is a dual main contribution in this study. At first the occupational health and safety issues of farmers of Odisha in India were analyzed based on the literature review and the data collected by personal interaction and questionnaires. In the second part, the step-wise weight assessment ratio analysis (SWARA) method was used to rank the different farming processes, as well as different risks involved in various farming activities.

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INTRODUCTION

Occupational health and safety (OHS) has been a major concern worldwide spreading from industrial to agriculture sectors. A variety of hazards having undesirable consequences are associated in farming like infection by pathogens, injuries from exposure, physiological disorders, poisoning, respiratory infections, and musculoskeletal disorders, etc. In terms of injuries and work related illness, agriculture has been ranked among the top three most hazardous occupational groups by the Centers for Disease Control and Prevention (CDC, 2013). Thus, the well being of farmers as well as the sustainability of agricultural sectors can be ensured by emphasizing on OHS issues within this sector (Jugmohan, 2013). It has been highlighted for the necessity of improving the existing laws, based on a study made from cases in Gujarat (India) to explore the ethical challenges in OHS (Patel et al., 2016). The agricultural system is governed by accumulated knowledge, technology, integrated value chains, institutional innovations (Byerlee et al., 2009), globalization (Von Braun et al., 2008) and physical, biological and cultural environment (Vasey, 2002). However, agriculture greatly affects the ecosystem by clearing of lands, fragmentation of habitats, variation in ecosystem, desertification, erosion of soil, loss of biodiversity, and eutrophication (Conway & Barbier, 2013; Fan et al., 2012; Rosset et al., 2000). The ecosystems are polluted (Conway & Pretty, 2013; Diaz & Rosenberg, 2008) and human health is affected (WHO, 1996) by the use of agrochemicals like pesticides and fertilizers. Most of the agricultural tools and equipments are made locally with the available materials such as woods, iron and stones (Karthikeyan et al., 2009). As these locally made tools lacks the ergonomic aspects in its design, so it results in more drudgery and work related accidents or injuries. It has been suggested to conceptualize the association between unsafe employment and occupational health (Quinlan et al., 2001).

There is a lack of organizational framework in the agricultural sectors needed for OHS management techniques to operate effectively. Thus within agricultural sector, it becomes essential worldwide to analyze the magnitude of OHS problems. However, there is a lack of study in Odisha (India) to assess the prevailing situations. Moreover, most of the farmers are unaware of the potential risks in their jobs and there are no educational extension programs addressing these issues. Hence an attempt was made in this study to explore the issues related to OHS among the farmers of Odisha in India. The findings in this study may have positive implications for extension programs and policy formulation in the sustainability of agricultural sectors.

BACKGROUND

The agricultural hazards are as a result of exposures to agrochemicals, psycho-social stresses, poor ergonomics, and poor physical working conditions (White et al., 1989). The use of chemicals in modern farming has become an essential element exposing farmers in direct contact to agro-chemicals, flowing of agro-chemicals in unprocessed areas, and residual contact of equipments and processed crops (Strong et al., 2008). Because of the lacking of personal washing facilities on the farm, the farmers are supposed to expose their families to agro-chemicals by taking their contaminated clothes to home (Quandt et al., 2010). Some of the instant or short term diseases on human health due to pesticide exposures are headaches, respiratory problems, coma, disorientation, rashes, vomiting & nausea, and shocks. Whereas, cancer, reproductive, and neurological problems are also caused as long term diseases (Arcury et al., 2002; Das et al., 2001; ILO, 1986). Heavy physical workloads and poor ergonomic working conditions, results in injuries and musculoskeletal disorders (Giuffrida et al., 2001). Neck, shoulder and back pain were most commonly observed in Ireland (Osborne et al., 2012). The performance of work and the associated work setting attributes greatly to the work related musculoskeletal disorders (Collins et al., 2011; Punnett et al., 2004). Kumar et al. (2013) have revealed the seriousness of work related musculoskeletal disorders and reported that the musculoskeletal disorders were because of prolonged exposure to loads having variable work intensities. A total of 36 agricultural injuries were reported during a year considering twelve villages of Punjab in India. Moreover, the injuries rate per thousand machines per year for tractors, sprayers, electric motors, threshers, and fodder cutters was 23.7, 15.5, 7.1, 5.7, and 2.2, respectively (Mittal et al., 1996). DeMuri et al. (2000) have highlighted that the injuries in agricultural sectors are as a result of lacking in proper supervisions, unreasonable expectations, economic troubles, and improper safety devices. Xiang et al. (2000) have conducted the face to face interview of 1358 Chinese farmers out of 1500 farmers considering 14 villages to evaluate the agricultural related injuries. A higher fatality rate and the injuries rate of 0.22, and 5 to 166 per 1000 workers per year were revealed in an agricultural survey in USA (Rautiainen et al., 2002). The agricultural accident rate was reported as 1.25 per thousand workers per year in Madhya Pradesh (India). It was further found that 77.6% of accidents were due to farm machineries, while 11.8% by the use of hand tools, and rest due to other reasons (Tiwari et al., 2002). As compared to the industrial workers, the injuries of farmers were reported to be higher (Helkamp et al., 2002). Kumar et al. (2008) have reported a total of 576 agricultural related injuries with hand tool related as 332 i.e. 58%, considering nine villages with 19,723 persons in 1st phase of their study. Additionally, in 2nd phase of study by considering more 21 villages with 78,890 persons 54 i.e.19% of hand tool related injuries out of 282 injuries was reported. It was further recommended to have intervention training and development activities at block levels for the safety measures of tools & equipments. In an investigation for the agricultural accidents between years 2000-2005, of 42 villages in Arunachal Pradesh (India) the accident rate was reported as 6.39 per thousand workers per year having farm implement related injury of 40% (Kumar et al., 2009). The workers and farmers engaged in livestock like dairy farms are subjected to adverse health risks (Karttunen et al., 2013). A total of 576 injuries in the agricultural sectors of Haryana in India were reported for 9 villages in a year. The injuries reported as minor were 87%, 11% as moderate and left over as severe. Most of the injuries were revealed of occurring because of hand tools like spades and sickles, bullock carts, manually and power operated fodder cutters, diesel engines and tractors (Mohan et al., 1992). By considering a total of 1000 farmers in Alabama limbs were found to be the most injured body part in agricultural accidents (Zhou et al., 1994). Giuffrida et al. (2001) have reported the adverse health effects on farmers by physical hazards due to noise, heat, vibrations, and other harmful climatic conditions. The psycho-social hazard to farmers occurs due to occupational stress and depressions. The study about the occupational stresses among farmers in India revealed that farming occupation causes high level of stresses, since farmers and their families work under the most stressful conditions such as financial problems, time pressures, diseases, government policies, heavy workloads, and unpredictable weather conditions (Ramesh et al., 2009). Effective interventions for reducing MSDs are the psychosocial and socio-cultural aspects of the work environment (Fathallah, 2010). Slips, trips, and falls on farms while performing agricultural activities were reported as the most important reasons of work related injuries among farmers (ACC, 2002). Moreover, the presence of wet, slippery, and muddy surfaces are the primary causes of slips, trips, and falls. A study in the Swedish agricultural industry revealed that injuries such as cuts, dislocations, and broken bones occur mainly from slips, trips, and falls. Furthermore, some injuries may result in permanent disability and can even be more serious & deadly (Lundqvist et al., 2012). There has been an increased food and fiber production leading to profits in agriculture with the use of pesticides. However, the use of pesticides is associated with the death of farm animals, human health risks, and in the alteration of local environment (Tchounwou et al., 2002; Calvert et al., 2001). The lower level exposures to one pesticide are greatly influenced by the associated exposure to other pesticides and to air, water, food and drugs pollutants (Akter et al., 2009). New tools or techniques having larger reliability than the existing are required to reduce the adverse effects pesticides on human health as well as the environment. Additionally, the alternative implementation of cropping systems with less dependency on pesticides, developing new pesticides with novel action modes and enhanced safety profiles, and the improvement of already used pesticide formulations towards safer formulations could reduce the adverse effects of farming.

Besides, the use of well-maintained and appropriate spraying equipment considering all precautions that are required in all stages of pesticide handling could minimize human exposure to pesticides as well as the potential adverse effects on the environment (Damalas et al., 2011). Farmers in remote agricultural areas are more affected by pesticide illness and poisoning, as these areas have inadequate occupational standards for safety, insufficient pesticide-related legislation enforcement, pesticide containers with poor labeling, illiteracy, inadequate protective clothing and washing facilities as well as lack of knowledge of hazards due to pesticides (Tchounwou et al., 2002; Snelder et al., 2008). Nag et al. (2004) have reported of the tractor related incidents such as overturning, falling from tractors, etc. as highest which was followed by the accidents due to threshers, sprayers, crushers, and chaff cutters. Further it was found that most of the fatal accidents were because of the use of the powered machineries. A major source of mortality and morbidity among workers are associated with occupational hazards (Driscoll et al., 2005). Animal workers in their daily practice have been reported to be exposed to various hazardous situations (Adedeji et al., 2011; Olowogbon, 2011). The awkward working postures, high rate of work, and deficiencies in the design of hand tools used in farm activities result in cumulative musculoskeletal strain and injuries (Vyas, 2014). The proportions of health problems are not the same for both men and women. Usually long static postures adopted by them for some of the activities increases the physiological costs as well as lower the productivity (Tripathi et al., 2013; Tripathi et al., 2015). Various types of physical hazards were reported among the farm workers engaged in dairy, poultry, piggery, husbandry and dealing with animals in a variety of agricultural activities (Driscoll et al., 2005; Stallones, 2011; Ghosh et al., 2014). Moreover the physical hazards occur due to slippery floors, dung pits, cages, and dusty feeding areas around the cattle, goat and sheep production units (Myers et al., 1997). A majority of workers in Nigeria, associated with livestock rearing were reported to be unaware of various preventive measures about work related risks and hazards. The prevalence of occupational hazards exposure was revealed as 69.6%, with hospitalization cases related to work of 6.5%, and occupational related sickness & diseases of 14.3% (Awosile et al., 2013). Over 5% of rural occupants were reported of suffering from ringworm infections. Moreover the chemical hazards were reported by both male and female respondents with a significant difference in its extent. It was found that the chemical hazards were due to use of chemicals in disinfection, decontamination, cleaning of animals (Chatterjee et al., 1980). Female farmers were reported to be more vulnerable to psychological hazards when compared to the male farmers (Malmberg et al., 1997; Melberg, 2003). A majority of workers in Nigeria, associated with livestock rearing were reported to be unaware of various preventive measures about work related risks and hazards (Awosile et al., 2013). The respondents taking the risk and perceiving the farm related injuries as inevitable were reported to have multiple injuries than those practicing safe farming such as operating machinery safely, and wearing of protective clothes (Harrell, 1995). Chikerema et al. (2013) have reported in a study in Zimbabwe, that less than half of the workers were aware of various preventive measures against work related diseases. The percentages of workers found of aware about the use of protective clothing, washing of hands after work periods, and good sanitary practices were 23.5%, 6.5%, and 7%, respectively. With the objective to guard animals, the farmers usually live with them under the same roof. This in turn increases the probability of exposing to zoonotic diseases having bacterial origin, like internal parasites such as tapeworms and ectoparasites such as fleas & mites (Nasinyama et al., 2000). In a study carried out in Odisha (India), it was observed that out of a total of 45 farmers, 43 farmers were victims of farm related accidents due to the use of hand tools (Mishra et al., 2018a). Dube et al. (2018) have made an ergonomic assessment for different postures of farmers of Odisha in India during seeding, fertilizing and weeding processes in agricultural field, and based on the obtained RULA scores, different action levels were suggested for the existing working techniques and methods. Mishra et al. (2018b) have studied the musculoskeletal disorders during threshing of crops for farmers in Odisha, and suggested to prefer ergonomic design of farming tools.

There is a dual main contribution in this study. At first the occupational health and safety issues of farmers of Odisha in India, were analyzed based on the literature review and the data collected by personal interaction and questionnaires. Based on the recommendations of different studies where the SWARA methods are used not only to determine the weight of criteria, but also to completely solve MCDM problems, in the second part the "Step-wise Weight Assessment Ratio Analysis (SWARA)" method was used to rank the different farming processes, as well as different risks involved in various farming activities.

Step-Wise Weight Assessment Ratio Analysis (SWARA) Method

The SWARA (Step-wise Weight Assessment Ratio Analysis) method developed by Kersuliene et al. (2010) is one of the methods used for determining weight values in a decision-making process. Alimardani et al. (2013) have used SWARA and VIKOR analysis as two multiple attribute decision-making (MADM) methods for agile supplier selection based on four criteria including performance, cost, flexibility and technology. SWARA was used for determining the importance of each criterion and calculating their relative weights, while VIKOR was used for evaluating and ranking from the best to the worst of the supplier alternatives. Zolfani et al. (2014) have used SWARA and COPRAS as two MCDM methods on decision and policy making of high tech industries in Iran. Finally they have concluded with Nanotechnology at the top priority in Iran and also recommended this methodology for other areas of research. An extended version of stepwise weight assessment ratio analysis (SWARA) was proposed for criteria evaluation in decision making. As SWARA analysis involves two important steps where the first is prioritization of the criteria by experts, and the second is the calculation of relative weights. The reliability evaluation of experts' idea into the first step of SWARA analysis was recommended to improve the quality of the decision-making process (Zolfani et al., 2018). The integration of the delphi technique and the adapted SWARA method was successfully applied for creating a set of evaluation criteria for the sales managers and for defining the relative weights of such criteria (Karabasevic et al., 2017). There are few approaches that are based on the idea of SWARA method and also SWARA extensions, such as: selecting of personnel with the use of the adapted weighted sum method based on the decision-makers preferred level of performances (WS PLP), and the SWARA Method (Stanujkic et al., 2017).

Based on Kersuliene et al. (2010) and Stanujkic et al. (2015), in this method the opinion of experts on the significance of criteria involved in a decision making process are obtained to form the list of criteria.

Then the below steps are followed.

Step 1: Criteria are sorted according to their significance.

In this step, the experts perform the ranking of defined criteria according to the significance. The most significant is placed in the first place, while the least significant is placed in the last place.

Step 2: Comparative importance of average values (s_j) are determined.

In this step, starting from the second ranked criterion, the significance values are determined i.e. how much the criterion c_j is more important than the criterion c_{j+1}.

Step 3: The coefficients (k_j) are calculated as follows:

$$k_j = \begin{cases} 1, j = 1 \\ s_j + 1, j > 1 \end{cases} \tag{1}$$

Step 4: The recalculated weights (q_j) are determined as follows:

Table 1. The characteristics of the decision-making experts

Field	Gender		Education Level		
	Male	**Female**	**Bachelor**	**Master**	**Doctor**
Agriculture	2	0	0	1	1
Health and Medicine	0	1	0	1	0
Environmental	1	0	0	0	1
Fishery	1	0	0	1	0
Industrial engineering	1	2	0	1	2

$$q_j = \begin{cases} 1, j = 1 \\ \dfrac{q_{j-1}}{k_j}, j > 1 \end{cases} \tag{2}$$

Step 5: The relative weights (w_j) of the evaluation criteria are determined as follows:

$$w_j = \frac{q_j}{\sum_{k=1}^{n} q_k} \tag{3}$$

where, n denotes the number of the criteria.

Research Methodology

This research was based on the detailed review of literature was carried out in this study related to the agricultural OHS issues and then identification of the risks associated with different farming activities in the agricultural sector of Odisha (India) was done. The identification of the farming risks and the subsequent ranking on the basis of their importance was done on the basis of the literature review, personal interaction with farmers during different farming activities, and opinion of decision making experts. The SWARA method was used in the study to calculate the weights and corresponding ranking of the criterion and sub-criteria. The characteristics of the decision-making experts are as shown in Table 1. The criteria's and sub-criteria are based on the risks associated with different farming activities, which were identified from the literature review is as shown in Table 2.

Table 2. Criteria and sub-criteria based on categories of the agricultural sector

Symbols	Criteria and Sub-Criteria
C_1	**Land preparation process**
$C_{1\text{-}1}$	Irritation from smoke during burning rice stalks, if any.
$C_{1\text{-}2}$	Musculoskeletal problems from lifting and carrying tools or equipments.
$C_{1\text{-}3}$	Injuries from hand start of plowing and harrowing machines.
$C_{1\text{-}4}$	Exposure to diesel fumes from plowing and harrowing tractors.
$C_{1\text{-}5}$	Exposure to loud noise from plowing and harrowing tractors.
$C_{1\text{-}6}$	Injuries from plowing and harrowing blades.
$C_{1\text{-}7}$	Exposure to vibration of plowing and harrowing machines.
$C_{1\text{-}8}$	Injuries during operation of plowing and harrowing tractors.
$C_{1\text{-}9}$	Injuries from stepping on shell.
$C_{1\text{-}10}$	Musculoskeletal problems from carrying heavy pumping hoses or pipes.
$C_{1\text{-}11}$	Musculoskeletal problems from incorrect working postures.
C_2	**Seed soaking and scattering/Fertilizer applying process**
$C_{2\text{-}1}$	Musculoskeletal problems from carrying heavy containers.
$C_{2\text{-}2}$	Puncture from bamboo sticks of seed containers.
$C_{2\text{-}3}$	Exposure to wet and humid soil.
C_3	**Pesticides mixing and spraying process**
$C_{3\text{-}1}$	Exposure to loud noise of pesticide applying machines.
$C_{3\text{-}2}$	Exposure to vibration of pesticide applying machines.
$C_{3\text{-}3}$	Injuries from falling of pesticide applying machines.
$C_{3\text{-}4}$	Musculoskeletal problems from carrying pesticides sprayers.
$C_{3\text{-}5}$	Symptoms from pesticide exposures, such as vomiting, skin irritations, nasal irritations, eye irritations, and headache.
C_4	**Weed pulling process**
$C_{4\text{-}1}$	Musculoskeletal problems from incorrect weeding postures.
$C_{4\text{-}2}$	Musculoskeletal problems from weeding by hand.
$C_{4\text{-}3}$	Musculoskeletal problems from weeding by machine.
C_5	**Rice harvesting process**
$C_{5\text{-}1}$	Injuries from manually operated harvester.
$C_{5\text{-}2}$	Exposure to vibration of harvesting machines.
$C_{5\text{-}3}$	Exposure to noise of harvesting machines.
$C_{5\text{-}4}$	Injuries while operating harvesting tractors.
$C_{5\text{-}5}$	Musculoskeletal problems from incorrect postures in harvesting.
$C_{5\text{-}6}$	Musculoskeletal problems from lifting heavy rice stacks.
C_6	**Threshing process**
$C_{6\text{-}1}$	Injuries from manually operated thresher by striking on wooden frame or using hand operated mechanical thresher or using draft animal driven thresher.
$C_{6\text{-}2}$	Exposure to vibration of threshing machines.
$C_{6\text{-}3}$	Exposure to noise of threshing machines.
$C_{6\text{-}4}$	Musculoskeletal problems from incorrect postures in threshing.
$C_{6\text{-}5}$	Exposure to grain dusts.

Results and Discussion

The most important criteria for this study as illustrated in Table 2 are land preparation process, seed soaking and scattering/fertilizer applying process, pesticides mixing and spraying process, weed pulling process, rice harvesting process, and threshing process, respectively. The sub-criteria's are the risks involved in different farming activities as illustrated in Table 2. The weights criteria and sub-criteria are calculated by using SWARA method as shown in Table 3-Table 9. The criteria's and sub-criteria's have been arranged according to the priorities defined by experts. The final ranking of criteria's and sub-criteria's are obtained considering their respective calculated weights (Table 10). Final weights of sub-criteria based on agricultural farming related risk in context of different criteria such as land preparation process, seed soaking and scattering/fertilizer applying process, pesticides mixing and spraying process, weed pulling process, rice harvesting process, and threshing process, are shown in Table 4-Table 9. It may be noted that the final weights of sub-criteria's are based on the respective weights of criteria's. The assessment scale is based on 5 percent steps. i.e., experts indicated a comparative and value differences on the basis of 5 percent increments: 5%, 10%, 15% and so on. Final numbers in this part are calculated from the arithmetic average of experts' ideas.

From the overall ranking of all five criterions, land preparation process ranked the first, followed by rice harvesting process, threshing process, weed pulling process, seed soaking and scattering/fertilizer applying process, and pesticides mixing and spraying process at the last rank, respectively. While considering the ranking of sub-criteria only, it was found that musculoskeletal problems from incorrect weeding postures in the criteria of weed pulling process ranked first, while musculoskeletal

Table 3. Final weights of Criteria's

Criteria	**Comparative Importance of Average Value** $\left(s_j\right)$	**Coefficient** $\left(k_j = s_j + 1\right)$	**Recalculated Weight** $\left(w_j = \frac{x_{j-1}}{k_j}\right)$	**Weight** $\left(q_j = \frac{w_j}{\sum w_j}\right)$
C_1		1	1	0.228
C_5	0.15	1.15	0.869	0.198
C_6	0.16	1.16	0.749	0.171
C_4	0.13	1.13	0.663	0.151
C_2	0.14	1.14	0.582	0.133
C_3	0.14	1.14	0.510	0.116

Table 4. Final weights of sub-criteria in context with land preparation process

Sub-Criteria	Comparative Importance of Average Value $\left(s_j\right)$	Coefficient $\left(k_j = s_j + 1\right)$	Recalculated Weight $\left(w_j = \frac{x_{j-1}}{k_j}\right)$	Weight $\left(q_j = \frac{w_j}{\sum w_j}\right)$	Final Weights
$C_{1\text{-}1}$		1	1	0.170	0.038
$C_{1\text{-}2}$	0.19	1.19	0.840	0.143	0.032
$C_{1\text{-}4}$	0.17	1.17	0.718	0.122	0.027
$C_{1\text{-}3}$	0.15	1.15	0.624	0.106	0.024
$C_{1\text{-}5}$	0.14	1.14	0.547	0.093	0.021
$C_{1\text{-}6}$	0.12	1.12	0.488	0.083	0.018
$C_{1\text{-}7}$	0.12	1.12	0.436	0.074	0.016
$C_{1\text{-}9}$	0.19	1.19	0.366	0.062	0.014
$C_{1\text{-}10}$	0.18	1.18	0.310	0.053	0.012
$C_{1\text{-}8}$	0.11	1.11	0.279	0.047	0.010
$C_{1\text{-}11}$	0.16	1.16	0.241	0.041	0.009

Table 5. Final weights of sub-criteria in context with seed soaking and scattering/ fertilizer applying process

Sub-Criteria	Comparative Importance of Average Value $\left(s_j\right)$	Coefficient $\left(k_j = s_j + 1\right)$	Recalculated Weight $\left(w_j = \frac{x_{j-1}}{k_j}\right)$	Weight $\left(q_j = \frac{w_j}{\sum w_j}\right)$	Final Weights
$C_{2\text{-}1}$		1	1	0.374	0.049
$C_{2\text{-}2}$	0.14	1.14	0.877	0.328	0.043
$C_{2\text{-}3}$	0.11	1.11	0.790	0.296	0.039

Table 6. Final weights of sub-criteria in context with pesticides mixing and spraying process

Sub-Criteria	Comparative Importance of Average Value $\left(s_j\right)$	Coefficient $\left(k_j = s_j + 1\right)$	Recalculated Weight $\left(w_j = \frac{x_{j-1}}{k_j}\right)$	Weight $\left(q_j = \frac{w_j}{\sum w_j}\right)$	Final Weights
$C_{3\text{-}1}$		1	1	0.264	0.030
$C_{3\text{-}2}$	0.18	1.18	0.847	0.223	0.025
$C_{3\text{-}4}$	0.16	1.16	0.730	0.192	0.022
$C_{3\text{-}3}$	0.13	1.13	0.646	0.170	0.019
$C_{3\text{-}5}$	0.15	1.15	0.561	0.148	0.017

Table 7. Final weights of sub-criteria in context with weed pulling process

Sub-Criteria	Comparative Importance of Average Value $\left(s_j\right)$	Coefficient $\left(k_j = s_j + 1\right)$	Recalculated Weight $\left(w_j = \frac{x_{j-1}}{k_j}\right)$	Weight $\left(q_j = \frac{w_j}{\sum w_j}\right)$	Final Weights
$C_{4\text{-}1}$		1	1	0.370	0.055
$C_{4\text{-}2}$	0.12	1.12	0.892	0.330	0.049
$C_{4\text{-}3}$	0.11	1.11	0.804	0.298	0.044

Table 8. Final weights of sub-criteria in context with rice harvesting process

Sub-Criteria	Comparative Importance of Average value $\left(s_j\right)$	Coefficient $\left(k_j = s_j + 1\right)$	Recalculated Weight $\left(w_j = \frac{x_{j-1}}{k_j}\right)$	Weight $\left(q_j = \frac{w_j}{\sum w_j}\right)$	Final Weights
$C_{5\text{-}1}$		1	1	0.224	0.044
$C_{5\text{-}2}$	0.13	1.13	0.885	0.198	0.039
$C_{5\text{-}6}$	0.11	1.11	0.797	0.178	0.035
$C_{5\text{-}4}$	0.16	1.16	0.687	0.153	0.030
$C_{5\text{-}5}$	0.16	1.16	0.592	0.132	0.026
$C_{5\text{-}3}$	0.18	1.18	0.501	0.112	0.022

Table 9. Final weights of sub-criteria in context with threshing process

Sub-Criteria	Comparative importance of Average Value (s_j)	Coefficient $(k_j = s_j + 1)$	Recalculated Weight $\left(w_j = \frac{x_{j-1}}{k_j}\right)$	Weight $\left(q_j = \frac{w_j}{\sum w_j}\right)$	Final Weights
$C_{6\text{-}1}$		1	1	0.252	0.043
$C_{6\text{-}3}$	0.15	1.15	0.869	0.219	0.037
$C_{6\text{-}4}$	0.11	1.11	0.783	0.197	0.033
$C_{6\text{-}2}$	0.13	1.13	0.693	0.174	0.029
$C_{6\text{-}5}$	0.12	1.12	0.618	0.155	0.026

problems from incorrect working postures in the criteria of land preparation process ranked the last as illustrated in Table 10.

CONCLUSION

In the present study considering different rice farming activities as different criteria for SWARA method, it was found that land preparation process ranked the first, followed by rice harvesting process, threshing process, weed pulling process, seed soaking and scattering/fertilizer applying process, and pesticides mixing and spraying process at the last rank, respectively. While considering the different risks involved in various farming activities as sub-criteria, it was found that musculoskeletal problems from incorrect weeding postures in the criteria of weed pulling process ranked the first, while musculoskeletal problems from incorrect working postures in the criteria of land preparation process ranked the last.

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Table 10. Overall ranking of all the criterion and sub-criteria

Symbols	Criteria and Sub-Criteria	Criteria Ranking	Sub-Criteria Ranking
C_1	**Land preparation process**	**1**	
C_{1-1}	Irritation from smoke during burning rice stalks, if any.		6
C_{1-2}	Musculoskeletal problems from lifting and carrying tools or equipments.		10
C_{1-3}	Injuries from hand start of plowing and harrowing machines.		16
C_{1-4}	Exposure to diesel fumes from plowing and harrowing tractors.		13
C_{1-5}	Exposure to loud noise from plowing and harrowing tractors.		18
C_{1-6}	Injuries from plowing and harrowing blades.		20
C_{1-7}	Exposure to vibration of plowing and harrowing machines.		22
C_{1-8}	Injuries during operation of plowing and harrowing tractors.		25
C_{1-9}	Injuries from stepping on shell.		23
C_{1-10}	Musculoskeletal problems from carrying heavy pumping hoses or pipes.		24
C_{1-11}	Musculoskeletal problems from incorrect working postures.		26
C_2	**Seed soaking and scattering/Fertilizer applying process**	**5**	
C_{2-1}	Musculoskeletal problems from carrying heavy containers.		2
C_{2-2}	Puncture from bamboo sticks of seed containers.		4
C_{2-3}	Exposure to wet and humid soil.		5
C_3	**Pesticides mixing and spraying process**	**6**	
C_{3-1}	Exposure to loud noise of pesticide applying machines.		11
C_{3-2}	Exposure to vibration of pesticide applying machines.		15
C_{3-3}	Injuries from falling of pesticide applying machines.		19
C_{3-4}	Musculoskeletal problems from carrying pesticides sprayers.		17
C_{3-5}	Symptoms from pesticide exposures, such as vomiting, skin irritations, nasal irritations, eye irritations, and headache.		21
C_4	**Weed pulling process**	**4**	
C_{4-1}	Musculoskeletal problems from incorrect weeding postures.		1
C_{4-2}	Musculoskeletal problems from weeding by hand.		2
C_{4-3}	Musculoskeletal problems from weeding by machine.		3
C_5	**Rice harvesting process**	**2**	
C_{5-1}	Injuries from manually operated harvester.		3
C_{5-2}	Exposure to vibration of harvesting machines.		5
C_{5-3}	Exposure to noise of harvesting machines.		17
C_{5-4}	Injuries while operating harvesting tractors.		11

continued on following page

Table 10. Continued

Symbols	Criteria and Sub-Criteria	Criteria Ranking	Sub-Criteria Ranking
$C_{5\text{-}5}$	Musculoskeletal problems from incorrect postures in harvesting.		14
$C_{5\text{-}6}$	Musculoskeletal problems from lifting heavy rice stacks.		8
C_6	**Threshing process**	**3**	
$C_{6\text{-}1}$	Injuries from manually operated thresher by striking on wooden frame or using hand operated mechanical thresher or using draft animal driven thresher.		4
$C_{6\text{-}2}$	Exposure to vibration of threshing machines.		12
$C_{6\text{-}3}$	Exposure to noise of threshing machines.		7
$C_{6\text{-}4}$	Musculoskeletal problems from incorrect postures in threshing.		9
$C_{6\text{-}5}$	Exposure to grain dusts.		14

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KEY TERMS AND DEFINITIONS

Agricultural Injury: It is the injury that occurs while performing farm work.

Biological Hazards: It refers to the biological substances which may cause harmful effects to the health of living organisms.

Chemical Hazards: It refers to the dangerous and poisonous chemicals which may cause harmful effects in the workplace.

Farming: Farming is a part of agriculture. It is the growing of crops or keeping animals by people for food and raw materials.

Injury: Injury is the damage to the body caused by external force. This may be caused by accidents, falls, hits, weapons, and other causes.

Occupational Health: It refers to the identification and control of the risks arising from physical, chemical, and other workplace hazards in order to maintain a healthy and safe working environment.

Physical Hazards: The factors or circumstances which may cause harmful effects with or without contact.

Psycho-Social Hazards: It refers to the risks to the mental and emotional health and safety of workers, such as job insecurity, poor work life balance, and long working hours.

Chapter 12
Supplier Selection Criterion for SSCM in Indian Thermal Power Plant:
Criteria Responsible for the Selection of Raw Material Provider in a Thermal Power Plant

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ABSTRACT

All companies are dependent on their raw material providers. The same applies in the case of thermal power plants. The major raw material for a thermal power plant is the coal. There are a lot of companies which in turn provide this coal to the thermal power plant. Some of these companies are international; some are local, whereas the others are localized. The thermal power plants look into all the aspects of the coal providing company, before settling down for a deal. Some people are specifically assigned to the task of managing the supply chain. The main motive is to optimize the whole process and achieve higher efficiency. There are a lot of things which a thermal power plant looks into before finalizing a deal, such as the price, quality of goods, etc. Thus, it is very important for the raw material providers to understand each and every aspect of the demands of the thermal power plant. A combination of three methods—Delphi, SWARA, and modified SWARA—has been applied to a list of factors, which has later been ranked according to the weight and other relevant calculations.

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INTRODUCTION

The electricity sector in India is growing very quickly, exhibiting great enthusiasm in generation of electricity. So to fulfill demand, India continues to invest in increasing electricity capacity fired by coal. As coal has proactive stance on climate action, so Clean energy, clean technology is the first requirement for all industries and coal power plants are mostly focused due to environmental degradation, logistics related emissions, waste production, non-disposability of by products and wastes and stressful work environment for its employees (Hussain, 2011). The awareness against the Environmental pollution and clean energy is increasing all over the world. As the thermal power sector is blamed for creating Environmental pollution, so they are more focused on sustainability issues and subsequently trying to develop a sustainable supply chain strategy to carry out their operations while respecting social as well as environmental issues. Sustainable supply chain management (SSCM) practices in Thermal power plant of India mostly dependent on three pillars (Social factor, Environmental factor, Economic factor).

The major raw material for a thermal power plant is coal. It is a fossil fuel and is depleting rapidly. However, there is a huge concern among the common people regarding the use of coal. People are aware of the harmful effects of burning coal and its contribution towards global warming. In order to reduce the number of pollutants released, the government has specified a lot of rules and regulation under which a company must operate. The government has also stated various companies to adopt a sustainable business model so that all the available resources stored in the earth for long run .

SSCM has a greener aspect to it as well as a social aspect. The greener or environmental apect looks to minimize the consequence of various supply chain related issues upon the environment. On the other hand, the social aspect of SSCM ensures ethical treatment and proper working conditions for all the personnel involved with the organization, including the suppliers. The SSCM also has a third aspect which looks after the economic upliftment of the local raw material providers. SSCM has been adopted in a wide range of companies. Thermal Power industries are no exception to it. There is a wide array of factors that influence SSCM. These factors can be majorly classified as

1. Factors promoting SSCM
2. Factors hindering SSCM

The first set of factor is those which promote the growth, spread and adoption of SSCM. The second set of criteria is those which hinder the growth of SSCM. There has been a lot of research involving and detailed structural study of these factors.

The factors responsible for promotion are enlisted in (Grzybowska, 2012; Faisal, 2010; Walker and Jones, 2012; Muduli and Barve, 2013; Diabat et al., 2014) and the barriers are enlisted (Bhattacharyya, 2010; Walker and Jones, 2012; Ageron et al., 2010).

SSCM is at its initial budding stage in India. Only handful of major companies in the thermal power plant sector has adopted SSCM at an operational level. The companies practising the methods of SSCM as well as the companies attached to them have witnessed a tremendous amount of growth.

LITERATURE REVIEW

To achieve Sustainability in Supply chain management supplier selection for thermal power industries is one of the most important issue. Many authors have implemented many methods to find supplier selection criteria for different industries. Xia (2006) and Tang (2004) have evaluated coal-fired supplier of thermal power companies using seven evaluation indicators.

Tan et.al.(2014) have Selected Ideal Coal Suppliers of Thermal Power Plants using the Matter-Element Extension Model with Integrated Empowerment Method for Sustainability.

Rising awareness about environmental and societal issues has created one of the greatest revolutions in human attention, uniting the entire world in a fight against the emissions which are produced during industrial activities (Dubey et al., 2015). Particularly the last decade has seen an increased pressure to broaden the accountability of the industries beyond economic performance, for shareholders to sustainability performance, for all stake holders (Labuschagne et al., 2005). Consequently an increased interest was exhibited by organizations in addressing sustainability in their supply chains, which has been described as Sustainable Supply Chains Management (SSCM) that incorporates the triple bottom line of sustainability (Walker and Jones, 2012). SSCM is the management of raw materials and services from suppliers to manufacturers/ service providers to customers and back with the improvement of the social and environmental impacts explicitly considered (Grzybowska, 2012).

Green or environmental aspect of SSCM focuses on minimization of the adverse environmental consequences of various activities of supply chains whereas the second one, social aspect of SSCM ensures ethical as well as decent working conditions of various stakeholders including the suppliers. The third component of the SSCM, the economic aspects ensures local economic generation through purchasing from local suppliers (Walker and Jones, 2012).

SSCM implementation in industries is influenced by a number of factors and there is no exception for the thermal power industries. These influential factors broadly can be divided into two categories:

- Enablers the factors that encourage SSCM adoption
- Barriers that hinder SSCM adoption.

The power sector is the biggest customer of coal, it depends on coal for power generation. As Coal is the maximum polluting material, so its transportation and storing is an important point. All over the world pollution is a headache and Environmental condition is the focused issue for discussion. So a lot of efforts are taken by Govt and research units .Media always debates and asks for suggestions and new developments that can resolve this problem. So researches are undergoing on this to find a better way to use coal without creating Environmental pollution. The current researchers have realized that, environmental and societal issues must be considered such that the greatest revolutions in human thought, uniting the entire world in a fight against the emissions which are produced during industrial activities (Dubey et al., 2015). Particularly the last decade has seen an increased pressure to broaden the accountability of the industries beyond economic performance, for shareholders to sustainability performance, for all stake holders (Labuschagne et al., 2005). Consequently an increased interest was exhibited by organizations in addressing sustainability in their supply chains, which has been described as Sustainable Supply Chains Management (SSCM) that incorporates the triple bottom line of sustainability (Walker and Jones, 2012). SSCM is the management of raw materials and services from suppliers to manufacturers/ service providers to customers and back with the improvement of the social and environmental impacts explicitly considered (Grzybowska, 2012).

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SSCM implementation in industries is influenced by a number of factors and there is no exception for the thermal power industries. These influential factors broadly can be divided into two categories; enablers the factors that encourage SSCM adoption and barriers that hinder SSCM adoption.

Enabler as defined in layman's term is "an entity that makes it possible or easy". Therefore enablers for sustainable supply chains are process that can drive a supply chain to being sustainable (Hussain, 2011).

Scanning of contemporary literature reveals that there exists a number of studies that focused exclusively either on the enablers (Grzybowska, 2012; Faisal, 2010; Walker and Jones, 2012; Diabat et al., 2014) or barriers (Bhattacharyya, 2010; Walker and Jones, 2012; Ageron et al., 2010). However, this study provides a framework to study both the categories factors simultaneously, so that it will be easy to identify the relative importance of an enabler with respect to a barrier. This in turn will enable the organizations to identify their degree of strength in handling a particular barrier.

SSCM is at its nascent stage in India; moreover, its adoption amongst Indian thermal power sector is limited to only few big companies. Hence, an analytical approach such as AHP has been proposed in this to study to analyze various influential factors of SSCM instead of statistical approach that depends upon bigger sample sizes. It has the ability to accommodate qualitative attributes in an organized manner and can be used to structure a system and its environment into mutually interacting elements and then to synthesize them by measuring and ranking the impact of these elements on the entire system (Sambasivan and Fei, 2008) with the objective or goal (SSCM implementation) occupying position at the top level of the hierarchy, various criteria and sub-criteria occupy positions in the subsequent level. of utility.

RESEARCH METHODOLOGY

To find the supplier selection criteria in Thermal power Industries, a standard questionnaire is designed that consists of 26 questions. Then 150 questionnaire is send to different Indian Thermal industries by post, mail and personal contact and the respondents are advised to respond each item of the Questionnaire in a five -point Likert-type scale (1 = totally disagree, 2 = partially disagree, 3 =No opinion, 4 =Partially agree, 5 = totally agree).The details of items in the questionnaire are given in Apendix.1.Among them 106 responses came and the response rate is more than 70%.Then the datas are fed for statistical analysis. Then SWARA method is implemented to rate supplier selection criteria in Thermal power Plant.

Result and Discussion

The collected data for supplier selection criteria in Indian thermal industries are subjected to various statistical analyses such as factor analysis and Kaiser–Meyer–Olkin (KMO) test. Factor analysis on 106 useful responses has been conducted using principal component method followed by varimax rotation via SPSS17.0. After analysis it is found that only 22 items are coming under four Dimensions (Credibility, Sustainability, fuel cost and fuel Quality). Percentage of total variance explained was found to be 72%, which is an acceptable value for the principal component varimax rotated factor loading procedure (Johnson and Wichern, 2002). The internal consistency of the actual survey data was tested by computing the Cronbach's alpha (α). The value of alpha for each dimension is shown in Tables 1 and 2. The value of KMO, which is a measure of sampling adequacy, was found to be 0.67 indicating that the factor analysis test has proceeded correctly and the sample used is adequate as the minimum acceptable value of KMO is 0.5 (Othman and Owen, 2001). Therefore, it can be concluded that the matrix did not suffer from multi colinearity or singularity. The result of Bartlett test of sphericity shows that it is highly significant (significance = 0.000) which indicates that the factor analysis processes is correct and suitable for testing multidimensionality (Othman & Owen, 2001). The factors coming after factor analysis are Fuel Quality, Fuel cost, Credibility of supplier and Sustainability.

Table.1 shows factor analysis.

The factors or dimensions of Table 1 are named in Table 2.

The constructs of Table.1 are given below.

- **Fuel Quality:** In order to reduce power generation variation costs of generation companies and ensure stable power generation earnings in the next period of time, generation companies need to evaluate coalfired supplier from fuel quality
- **Fuel Cost:** Fuel costs are the major affecting factor, generally accounting for more than 75% of total variable costs.
- **Credibility:** The quality of suppliers being convincing or believable by the consumer.
- **Sustainability:** It is the property of biological systems to remain diverse and productive indefinitely. Then Delphi method and SWARA method is implemented.
- **Delphi Method:** The Delphi method is a technique that is used to forecast the outcomes of a particular prescribed set of events on the basis of conclusions from a panel of experts. The panel of the experts is the only and most important factor of the Delphi method. This panel of experts includes experienced personnel both from within the organization as well as outside the organization. All the personnel involved are anonymous to one another. Thus, w fair judgment is assured. The panel answers a set of questions, which is then transferred among them after filtering out the irrelevant data. The facilitator coordinates the activity and makes the transfer of data smooth. Conclusions are brought together, analyzed and if found conflicting with one another then the process is carried out again.
- **SWARA Method:** SWARA stands for Step-wise Weight Assessment Ratio analysis. It was proposed by Kersuliene et al in the year 2010. In this method,

Table 1. Factor Analysis for Thermal power plant supplier selection criteria

	Item	Factor1	Factor2	Factor3	Factor4	Chrobanch's alpha
Credibility	1	0.631				0.669
	3	0.579				0.743
	15	0.618				0.557
	16	0.615				0.532
	25	0.593				0.579
	26	0.712				0.515
Sustainability	2		0.766			0.590
	5		0.600			0.616
	8		0.536			0.590
	10		0.576			0.699
	11		0.667			0.573
	12		0.632			0.586
	13		0.635			
Fuel Quality	6			0.639		0.523
	7			0.592		0.546
	9			0.651		0.613
	23			0.630		0.623
	24			0.517		0.556
Fuel cost	17				0.553	0.719
	18				0.559	0.543
	19				0.731	0.752
	20				0.599	0.612

an appeal is made to the experts in order to assign weight to each and every criterion. It has been applied to a wide range of problems such as architect selection (Kersuliene& Turskis, 2011), wall insulation (Ruzgys et al., 2014) etc. The procedure that is followed during this method is diagrammatically shown below

Starting from the j^{th} criteria, the various calculation steps involved are

Table 2. Naming of constructs

Supplier's Selection Criteria
1. Associated services
2. Clean programs
3. Delivery
4. Personal relationships
5. Waste Management
6. Quality
7. Reliability
8. Reverse logistics
9. Geography proximity
10. Reducing carbon footprint
11. Green Transportation channels
12. Environmental issues
13. Eco-design
14. Information technology and systems
15. Confidence
16. Source of competition among suppliers
17. Investment in high-end technology
18. Economic dependency
19. Service rate
20. Price

$$k_j = \begin{cases} 1 & j = 1 \\ s_j + 1 & j > 1 \end{cases} \qquad q_j = \begin{cases} 1 & j = 1 \\ \dfrac{q_{j-1}}{k_j} & j > 1 \end{cases} \qquad w_j = \frac{q_j}{\sum_{k=1}^{n} q_k}$$

where $k_{j=}$ coefficient of j^{th} criteriaq_j= recalculated weight of j^{th} criteriaw_j=relative weight of j^{th} criteria

SWARA and Modified SWARA

After complete and detailed study of various factors was carried out. A long list, comprising of 20 factors were prepared. This list of factors was made after a thorough literature survey and by consulting a group of experts. This list of factors was then distributed to different thermal power plant companies via the postal services. The personnel at various thermal power plants were asked to arrange the factors according to their preference. They were also given the provision of adding up factors to the list in case if they gave preference to something other than on the list. Along with it, they were also asked to rate the factors. A rating out of five was obtained by likert scale.

SWARA method could be directly applied with respect to the weight assigned to every factor. However, in order to apply modified SWARA, certain alterations were to be made. Firstly, all the criteria were sorted in descending order, depending upon the cumulative weight assigned to every factor. The factors were given relative weight. The formula applied to calculate the relative weight of criteria with respect to the previous one in the list is-

$$S_i = 1 - (P_i/100)$$

where

S_i = relative weight

P_i = significance of the criteria, expressed in percentage

However, an anomaly was noted when the ranking was carried out on the mean value. Some of the criteria attained a very high rank even though they were chosen by a very small group of people. This was because the small group of people assigned a very high weight to them. For avoiding this, the following formula was applied which gave equal importance to the mean weight of the criteria and sum of the criteria. The formula is

$$L_i = \lambda o' + (1-\lambda)o''$$

where

λ = coefficient. Lies between [0,1].

o' = rank on basis of mean weights.

o'' = rank on basis of the sum of weights.

l = rank on basis of above two factors.

Table.3 shows the list of criterion obtained from Delphi method.
Table .4 shows the occurrence of criterion.
Table.5 shows the calculation of weights and ranking.
Table.6 shows the modified SWARA calculation.
Table.7 shows that variables like Quality of coal, service rate, Green transportation channel are most important supplier selection criterion ranked high. So not only privatized sector, Nationalized and imported coals must also very careful to provide better service by improving Coal Quality, Service rate and Improving transportation channel.

CONCLUSION

Supplier selection difficulty has become one of the most vital issues for establishing an effective supply chain system. For many years, the conventional approach to supplier selection has been to select suppliers exclusively on the basis of price. But as companies have learned that the only importance on price as a single criterion for supplier selection is not sufficient, they have changed this criterion to multi-criteria approach. Now, these criteria have become more complex as environmental, social, political, and customer satisfaction factors are added to the traditional factors of quality, delivery, cost, and service. The use of multiple suppliers offers greater flexibility due to the diversification of the firm's total requirements and fosters competitiveness among alternative suppliers. Keeping in view the strategic importance of the supplier's role in the functioning of supply chains the researchers

Table 3. The final list of criteria after Delphi method

Supplier Criteria			
1. Associated services	8. Reverse logistics	15. Confidence	22. Savings from packaging
2. Clean programs	9. Geography proximity	16. Source of competition among suppliers	23.. Size
3. Delivery	10. Reducing carbon footprint	17. Investment in high-end technology	24. Certification ISO 14001
4. Personal relationships	11. Green Transportation channels	18. Economic dependency	25. Company's future plan
5. Waste Management	12. Environmental issues	19. Service rate	26. Lean management
6. Quality	13. Eco-design	20. Price	27. Flexibility
7. Reliability	14. Information technology and systems	21. Long-term relationships	28 Production resources system

Table 4. Occurrences of each criterion were noted

Criteria	Number of Occurrences
Green Transportation channels	63
Quality	14
Service rate	77
Delivery	49
Waste Management	35
Reliability	63
Eco-design	42
Information technology and systems	21
Geography proximity	84
Savings from packaging	84
Personal relationships	35
Size	56
Environmental issues	70
Price	21
Flexibility	21
Reducing carbon footprint	74
Source of competition among suppliers	49
Company's future plan	49
Clean programs	21
Long-term relationships	49
Production resources system	35
Confidence	35
Lean management	14
Associated services	35
Reverse logistics	34

have developed number of criteria, methods and models for supplier selection. So in this paper the supplier selection criterion is focused by considering the issues of supply chain management of coal in thermal powerplant.

Table 5. Calculation iteration -1 SWARA

Criteria	Comparative Importance of I Criteria to i-1 Criteria (Si)	Coefficient Ki=1+Si	Recalculated Weight q	Relative Weights q/ (Sum of Recalculated Weights)	Ranking on Basis of Relative Weights (O1)
Green Transportation channels	0.3877778	1.388	1	0.24	1
Quality	0.0885	1.089	0.919	0.22	2
Service rate	0.3027273	1.303	0.705	0.17	3
Delivery	0.3528571	1.353	0.521	0.13	4
Waste Management	0.766	1.766	0.295	0.07	5
Reliability	0.2644444	1.264	0.233	0.06	6
Eco-design	0.7733333	1.773	0.132	0.03	7
Information technology and systems	0.56	1.56	0.084	0.02	8
Geography proximity	0.2766667	1.277	0.066	0.02	9
Savings from packaging	0.3341667	1.334	0.05	0.01	10
Personal relationships	0.538	1.538	0.032	0.01	11
Size	0.47125	1.471	0.022	0.01	12
Environmental issues	0.327	1.327	0.016	0	13
Price	0.09325	1.093	0.015	0	14
Flexibility	0.41	1.41	0.011	0	15
Reducing carbon footprint	0.4192857	1.419	0.008	0	16
Source of competition among suppliers	0.42	1.42	0.005	0	17
Company’s future plan	0.4528571	1.453	0.004	0	18
Clean programs	0.55	1.55	0.002	0	19
Long-term relationships	0.3357143	1.336	0.002	0	20
Production resources system	0.64	1.64	0.001	0	21
Confidence	0.338	1.338	8E-04	0	22
Lean management	0.4	1.4	6E-04	0	23
Associated services	0.518	1.518	4E-04	0	24
Reverse logistics	0.41	1.41	3E-04	0	25
	Sum of recalculated weights		4.126		

Table 6. Iteration 2 modified SWARA

			LAMDA=0.5		
Criteria	**Total Weight Assigned**	**Ranking on Basis of Total Weights (O2)**	**A1=LAMDA x O1.**	**A2= (1-LAMDA) x 02**	**L= A1+A2**
Green Transportation channels	3306	9	1653	0	1653
Quality	10938	1	5469	4.5	5474
Service rate	4602	6	2301	0.5	2302
Delivery	2718	11	1359	3	1362
Waste Management	702	25	351	5.5	357
Reliability	3972	8	1986	12.5	1999
Eco-design	816	21	408	4	412
Information technology and systems	792	23	396	10.5	407
Geography proximity	5208	3	2604	11.5	2616
Savings from packaging	4794	5	2397	1.5	2399
Personal relationships	1386	18	693	2.5	696
Size	2538	12	1269	9	1278
Environmental issues	4038	7	2019	6	2025
Price	10881	2	5440.5	3.5	5444
Flexibility	1062	20	531	1	532
Reducing carbon footprint	4878	4	2439	10	2449
Source of competition among suppliers	2436	13	1218	2	1220
Company's future plan	2298	14	1149	6.5	1156
Clean programs	810	22	405	7	412
Long term relationships	2790	10	1395	11	1406
Production resources system	1080	19	540	5	545
Confidence	1986	15	993	9.5	1003
Lean management	720	24	360	7.5	368
Associated services	1446	17	723	12	735
Reverse logistics	1770	16	885	8.5	894

Table 7. Ranking

Criteria	Ranking on Basis of Relative Weights (O1)	Ranking on Basis of Total Weights (O2)	L= A1+A2	Cumulative Rank =(O1+O2+L)/3	Final Rank on Swara and Mod SWARA
Green Transportation channels	1	9	1653	5	3
Quality	2	1	5473.5	1.5	1
Service rate	3	6	2301.5	4.5	2
Delivery	4	11	1362	7.5	7
Waste Management	5	25	356.5	15	13
Reliability	6	8	1998.5	7	5
Eco-design	7	21	412	14	11
Information technology and systems	8	23	406.5	15.5	14
Geography proximity	9	3	2615.5	6	4
Savings from packaging	10	5	2398.5	7.5	7
Personal relationships	11	18	695.5	14.5	12
Size	12	12	1278	12	10
Environmental issues	13	7	2025	10	9
Price	14	2	5444	8	8
Flexibility	15	20	532	17.5	16
Reducing carbon footprint	16	4	2449	10	9
Source of competition among suppliers	17	13	1220	15	13
Company’s future plan	18	14	1155.5	16	15
Clean programs	19	22	412	20.5	19
Long-term relationships	20	10	1406	15	13
Production resources system	21	19	545	20	18
Confidence	22	15	1002.5	18.5	17
Lean management	23	24	367.5	23.5	20
Associated services	24	17	735	20.5	19
Reverse logistics	25	16	893.5	20.5	19

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APPENDIX

Table 8. Questionnaire on supplier's selection criteria

Supplier's Selection Criteria						
1.	Associated services	1	2	3	4	5
2.	Clean programs					
3.	Delivery					
4.	Personal relationships					
5.	Waste management					
6.	Quality					
7.	Reliability					
8.	Reverse logistics					
9.	Geography proximity					
10.	Reducing carbon footprint					
11	Green transportation channels					
12.	Environmental issues					
13.	Eco-design					
14.	Information technology and systems					
15.	Confidence					
16.	Source of competition among suppliers					
17.	Investment in high end technology					
18.	Economic dependency					
19.	Service rate					
20.	Price					
21.	Long term relationships					
22.	Savings from packaging					
23..	Size					
24.	Certification ISO 14001					
25.	Company's future plan					
26.	Lean management					
27.	Flexibility					
28	Production resources system					

Chapter 13
An Analysis on Sustainable Supply Chain Management in Thermal Power Plants:
Sustainable Supply Chain Management for Customer Satisfaction in the Thermal Power Sector

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ABSTRACT

Research on sustainable supply chain management (SSCM) has been garnering interest because of its multi-approach in nature. SSCM has emerged as an essential method for organizations to develop and to enhance their competitive strategy through innovative ways in order to satisfy customer basic needs. It facilitates competitive advantage, faster flow of information, material, less response time, speeding up delivery action, better relation and coordination among partners, easy way of information sharing, and increasing order fulfilment rate. Implementing SSCM in organizations like thermal power plants has other benefits such as increasing attention about environmental performance intending the integration of social as well as economic performance. In this chapter, the artificial neural network (ANN) method is used to measure the customer satisfaction after implementing SSCM by thermal power industries.

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INTRODUCTION

Supply Chain Management is a component of Operations Management because of many issues of operations management are related with supply chain management. Supply chain management and operations management both are indispensable for success of a business. Supply chain management is an external activity concerned with flow of resources, information and coordination among suppliers to optimise the entire process from supply to delivery of value along a supply chain. But operations management is related with the actions taken inside the factory to carry out production process by controlling and monitoring every facet of the business organisation. A tutorial is explored on the current research of operations management of logistics and supply chain and clarifies the conception of logistics and supply chain management with its different issues from different research angles (Li, 2014). Different ways are proposed and analysed to accomplish the validity and testing the models for operations and supply chain management through exploratory research and developed theory to minimize the gap between the research study and the real world application (Singhal et al, 2012). Also various ways are proposed and analysed to accomplish the opportunities for radical innovations in operations and supply chain management (O&SCM): pursuing all phases of science and multiple perspectives (Singhal et al, 2012). A framework is proposed and demonstrated for a content analytic approach to measuring theoretical constructs in operations and supply chain management (Tanpong, 2011). It is concluded with a reflection on the career development of operation and supply chain management scholars, their potential role as academics or practitioners, in the development of O & SCM theory and practice (Coughlan et al, 2016).

Coal is the world's most profuse and widely disseminated fossil fuel and the greatest single wellspring of vitality for power generation and its offer is growing gradually. Coal fired power plants also known as thermal power plants, give more than 42% of worldwide power generation, and is probably going to remain a key part of the fuel mix for power generation to take care of power demand, particularly the growing interest in developing nations like India. Coal holds for a wide range of coal assessed to be around 990 billion tons, enough for a long time at current utilization. Coal assumes a fundamental part especially for power generation, yet we have to utilize it productively and diminish its ecological impact. In the meantime, these plants represent more than 28% of worldwide carbon dioxide ($C0_2$) emissions. Conveying clarity to the performance measurement and $C0_2$ emissions is a criterion to the more economical utilization of coal at power plants. The productivity of changing over coal into power matters: less proficient power plants utilize more fuel and emanate more impact on air and water pollutions. The wasteful utilization of coal is unwanted and avoidable; it squanders a characteristic asset and prompts pointless toxin and ozone harming environment.

The current researchers have realized that, environmental and societal issues must be considered such that the greatest revolutions in human thought, uniting the entire world in a fight against the emissions which are produced during industrial activities (Dubey et al, 2015). Particularly the last decade has seen an increased pressure to broaden the accountability of the industries beyond economic performance, for shareholders to sustainability performance, for all stake holders (Labuschange et al, 2005). Consequently an increased interest was exhibited by organizations in addressing sustainability in their supply chains, which has been described as Sustainable Supply Chains Management (SSCM) that incorporates the triple bottom line of sustainability (Walker, 2012). SSCM is the management of raw materials and services from suppliers to manufacturers/service providers to customers and back with the improvement of the social and environmental impacts explicitly considered (Grzybowska, 2012). Green or environmental aspect of SSCM focuses on minimization of the adverse environmental consequences of various activities of supply chains whereas the second one, social aspect of SSCM ensures ethical as well as decent working conditions of various stakeholders including the suppliers. The third component of the SSCM, the economic aspects ensures local economic generation through purchasing from local suppliers (walker, 2012). SSCM implementation in industries is influenced by a number of factors and there is no exception for the thermal power industries. These influential factors broadly can be divided into two categories; enablers the factors that encourage SSCM adoption and barriers that hinder SSCM adoption. Enabler as defined in layman's term is "an entity that makes it possible or easy". Therefore enablers for sustainable supply chains are process that can drive a supply chain to being sustainable (Govindan et al, 2016).

SSCM in an organizations like thermal power plants the other benefits such as increasing attention about environmental performance intending the integration of social as well as economic performance (Hussain et al, 2016; De Giovanni et al, 2012). Coal based thermal power plants are more concerned with environmental issues. It is more valuable and advantage by adopting SSCM which enables environmental benefits to reduce CO_2 emission, greenhouse gas emission, effluents, solid wastes (Zhu et al, 2007). increasing recycling and reuse (Tsoulfas et al, 2006; Su et al, 2016). enhancing energy and material efficiency and producing eco-friendly products and services (Gonzalez-Moreno et al, 2016). Implementing of SSCM in thermal power industries permits to enhance economic performances like improvement in productivity (Arora et al, 2014; Green et al, 2012), reduction of cost of material and energy use in the process increasing global competitiveness (Garg et al, 2014; Zailani et al, 2012; Rao et al, 2005), increase in profit margin as well as its share value in the market. Implementation of SSCM conception in Indian thermal power industries is anticipated to increase social performances such as enhancement of corporate image ("Companies in Malaysia", 2011; Zhu et al, 2010) increase in customer response and their satisfaction level (Luthra et aal, 2013; Luthra et al, 2011; Azevedo et al, 2011). Implementing of SSCM also enables to benefit reduction of cost of fine and environmental accidents, less in environmental risk by preventing pollution, improvement in eco-friendly quality of Products and services (Azevedo et al, 2011). Therefore implementing SSCM in coal based thermal power industries enables a lots of benefit in a multidimensional direction keeping in view of triple bottom line facets as key elements.

The social dimension of sustainability relates to the human capital of the supply chain. Improving sustainability with respect to the social dimension involves developing and maintaining business practices that are fair and favorable to the labor communities and regions touched by the supply chain. Social performance indicators are grouped into three categories. l) Workplace: Refers to the internal human resources, those who work within the supply chain. 2) Community: Refers to all people outside of the supply chain including those who are directly and indirectly affected by the chain's performance. 3) Institutions/Systems: Refers to the internal and external systems procedures and values that relate to the social dimension.

The term environment characteristically refers to the natural environment. Improving environmental sustainability means reducing the ecological footprint of the supply chain. Out of the three dimensions, the environmental aspect of supply chain management has been studied the most. More than 50 environmental performance indicators has been identified by which suppliers can be evaluated (Handfield et al, 2002). There are many factors also identified related to environmental sustainability (Labsuchange et al, 2005). We divide the environmental factors into six categories. 1) Air: Refers to the local impacts, such as carbon monoxide emissions, as well as global impacts, such as ozone depletion. 2) Water: Refers to both quality and quantity impacts, e.g. toxic discharges as well as total usage. 3) Land: Refers to how much land is used, how it is used, and the impacts of the use, such as soil pollution. 4) Materials: Refers to quantity of material used, the type of material used, and the potential effects of that material. 5) Minerals and energy: Refers to the use of non-renewable mineral and energy resources. 6) Institutions/Systems: Refers to the values. Procedures and systems, both internal and external that relate to the environment.

Economic factors are sorted into four categories. 1) Economic performance: Refers to the ability of the firm to carry out its operations as well as the market value of the firm. 2) Financial health: Refers to well-being and long-term viability of the firm with respect to financial resources. 3) Market and structure: Refers to health of the market and the configuration of the supply chain. 4) Institutions/Systems: Refers to the internal and external systems procedures, and values that relate to the economic dimension.

The sustainability perfonnance measurement of coal-fired power plants consistently through a competitive environment is not as straightforward as it might appear. It is especially imperative at the worldwide level, yet noteworthy local contrasts exist. So also, at the local level, the individual performance of generating units and power plants must be thought about if measured reliably. For multifaceted sustainability concerns this is not straight forward, as less rules and regulations on sustainability performance measurement exist, particularly as to social issues. Using tools for performance measurement and supply chain management frameworks should be produced and actualized over a few accomplices in the supply chain to confirm valid and consistent information. Various methodologies have been proposed and created over the previous decades to deal with measurement of SSCM, including the sustainability balanced scorecar life cycle appraisal or product carbon footprint (Hevani et al, 2005; Schaltegger et al, 2008; Gold set al, 2010). In this paper AHP (Analytical Hierarchy Process) method is adopted because of its enormous fields of applications and being a better effective decision making tool as compared to other techniques like ELECTRE and TOPSIS, though they have been used for same applicability (Luthra et al, 2016; Shen et al, 2015; Mathiyazhagan et al, 2014; Mangla et al, 2015; Ghandi et al, 2016; Kumar et al, 2015). Therefore we implement an AHP method to evaluate customer satisfaction related to the adoption of sustainability initiatives in supply chain management followed by ANN (Artificial Neural Network) methodology a multi criteria decision making approach in thermal power plants. In this Paper, SSCM implementation occupying position at the top level of the hierarchy, various criteria and sub-criteria occupy positions in the subsequent level.

BACKGROUND

SSCM is at its nascent stage in India: moreover, its adoption amongst Indian thermal power sector is limited to only few big companies. Hence, an analytical approach such as AHP has been proposed in this to study to analyse various influential factors of SSCM instead of statistical approach that depends upon bigger sample sizes. The Analytic Hierarchy Process (AHP) is a structured methodology and multi-criteria decision-making approach dealing with effective decision making problems (Saaty et al, 1997; Wind et al, 1980; Saaty, 1990; Saaty, 1994; Saaty, 2008). It is a very powerful tool used for organizing, analysing and hierarchical decomposition of complex decision problems for different objectives, alternatives, criteria and sub-criteria (Mangla et al, 2015; Wind et al, 1980;Govindan et al, 2015; Yucener et al, 2011). AHP can be used to solve the problems related with both tangible and intangible factors (Dyer et al, 1992; Dyer et al, 2992; Luthra et al, 2015). AHP assist the decision maker to take more effective decision by setting the priorities. AHP helps to synthesize the results by articulating both dependent and independent features of a decision making process. It incorporates a suitable methodology to check the uniformity and to reduce the bias of the evaluation process by the decision maker. AHP has been applied in various decision making applications such as Supply Chain Management, Heath care, Manufacturing, Education, Engineering, Research and Design (Luthra et al, 2015; Ordoobadi et al, 2010). In this paper AHP method is adopted because of its enormous fields of applications and being a better effective decision making tool as compared to other techniques like ELECTRE and TOPSIS, though they have been used for same applicability 57]. Therefore we implement an AHP method to evaluate customer satisfaction related to the adoption of sustainability initiatives in supply chain management followed by ANN methodology a multi criteria decision making approach in thermal power plants.

The ANN is a Multi Criteria Decision Making tool gives the results with more accuracy having prediction error less than 20% (Qazi et al, 2015; Chai et al, 2013; Kuo et al, 2010). It is a computational model based on the structure and functions of biological neural networks. It is competent to manage many input uncontrolled parameters, which make it more precise and reliable. An ANN is concerned with group of connected units or nodes called artificial neurons. Each linking between artificial neurons can transfer a signal from one to other. The artificial neuron that obtains the signal can process it and then signal artificial neurons linked to it. It has the ability to accommodate qualitative attributes in an organized manner and can be used to structure a system and its environment into mutually interacting elements and then to synthesize them by measuring and ranking the impact of factors or elements on the entire system (Sambasivan, 2008) with the objective or goal. The matter discussed about neural network and explained that neural network can effectively exploit and represent the non-linear relationship between the consumer satisfaction and their perception of the service, it can be used for modelling of a customer's decision making (Mittal et al, n.d.). For effective evaluation and measurement of quality, neural networks based on back propagation algorithm are widely used to model qualitative and intangible aspects of different service sectors. ANN has applied for forecasting of service problems in aircraft structural component grouping (Nordmann et al, 2000). The decision is taken on surface modelling of apparel retail operations using ANN approach (Brandenburg et al, 2014). Hu, M.Y.

et al. (2004) It is evaluated that ANN gives more accurate result in the modelling of foreign equities than logistic regression. A model is developed for buying and selling timing prediction system using ANN for Tokyo stock exchange (Kimoto et al, 1990). A model of back propagation was found for prediction of bankruptcy by ANN (Odom et al, 1990). ANN has applied to test the service satisfaction in electricity service (Satapathy et al, 2014). A systematic assessment has developed of the sustainability of water services provided to the consumers in rural, urban and municipality area in India by neural network method (Satapathy et al, 2012). After using ANN methodology in thermal power plant, SSCM implementation occupying position at the top level of the hierarchy and various criteria and sub-criteria occupy positions in the subsequent level.

Using the equation, to find out $H = 2\sqrt{(I+1}$, as recommended by software, where H is the number of nodes in the hidden layer, I is number of nodes in input layer. All data to be expressed between the values 0-1 in a common scale for Normalization of raw data. During the training phase, learning rate and momentum coefficient are set at 25% and 20% respectively. The numbers of correct outputs were noted till the Root Mean Square Error (RMSE) is minimized to a reasonable value. Sensitivity analysis is used to study the impact of changes in service performance along the various items (inputs) of SSCM measuring practices against Output (i.e. benefits of SSCM practice). The model was run by varying the learning parameter, momentum parameter and number of cycles till RMSE is minimized. Both the learning parameter and momentum parameter are set at 0.25 and 0.20 to obtain the best results. The model is run for different number of cycles for different outputs till RMSE of 0.01 is achieved. Training of the network is stopped at this point. In order to find the robustness of the proposed model, sensitivity analysis was carried out. Sensitivity analysis is used to find the impact of SSCM practices measurers on nine outputs or benefits achieved after implementations.

RESEARCH METHODOLOGY

Thermal industries are in an urge to get profit, fulfill demand and show maxi mum benefit which they deserve to achieve by implementing SSCM in their regular practice. So to find the measuring criteria which are not helping in achieving the goal of SSCM implementation in thermal power industries, a standard questionnaire is designed that consists of 34 questions for economic performance, 37 social questions and 22 questions for environmental factors. Then 100 number of questionnaire is sent to different Indian thermal industries by post, mail and personal contact and the respondents are advised to respond each item of the questionnaire in a five-point

Likert-type scale (1 = totally disagree, 2 = partially disagree, 3 = No opinion, 4 = partially agree, 5 = totally agree). The details of items in the questionnaire are given in the Appendix. Among them 70 responses received and the response rate is 70%. Then the data are analyzed by statistical analysis like Principal component analysis to find the items or questionnaire falling under three dimensions or pillars of SSCM like Social, Environmental and Economic factors. Percentage of total variance explained was found to be 71%, 73.3% and 70.9% respectively which is an acceptable value for the principal component varimax rotated factor loading procedure (Wichern et al, 1992). The internal consistency of the actual survey data was tested by computing the Cronbach's alpha (α). The value of alpha for each dimension is shown in Tables 1, Table 4 and Table 7. The value of KMO, which is a measure of sampling adequacy, was found to be 0.55 and 0.57 and 0.61 indicating that the factor analysis test has proceeded correctly and the sample used is adequate as the minimum acceptable value of KMO is 0.5. Therefore it can be concluded that the matrix did not suffer from multicollinearity or singularity. The result of Bartlett test of sphericity shows that it is highly significant (significance = 0.000) which indicates that the factor analysis processes is correct and suitable for testing multidimensionality (Orthman et al, 2010).

Result Discussion

The collected data against three pillars of SSCM in Indian thermal industries are subjected to various statistical analysis such as factor analysis and Kaiser-Meyer-Olkin (KMO) test. Factor analysis on 72 useful responses has been conducted using principal component method followed by varimax rotation via SPSS 22.0. After analysis it is found that only 11 items are coming under three dimensions of Social factor, 13 items under six dimensions of Environmental factors and 10 items coming under four dimensions of Economic factors of SSCM. The factors coming after factor analysis under social dimension are Workplace/Internal, Institutions/Systems, and Community/External. The factors coming under environmental dimension are Air, Water, Land, Materials, Mineral and energy resources, Institutions/systems and the factors coming under economic dimension are economic performance, financial health, market and structure and Institutions/Systems. Table 1 shows the constructs Workplace, community and Institutions or systems are coming under Social factors of SSCM and Table 2 mentions the items coming under social factors. Table 3 shows the dimensions like Air, Water, Land, Material, Minerals and energy and Institutions coming under the umbrella of environmental factor and Table 4 shows the items of environmental dimensions. The economic dimension of the supply chain refers to the profits earned by the members of the chain as well as the economic benefits realized by the host nations, regions, and communities of those members.

Table 1. Social factor

	Item	Factor1	Factor2	Factor3	Chrobanch's Alpha
Workplace/Internal	15	0.838			0.757
	16	0.796			0.668
	17	0.678			0.534
	23	0.737			0.539
	36	0.609			0.558
Community/External	12		0.529		0.601
	21		0.562		0.594
	24		0.736		0.531
	25		0.692		0.512
	32		0.691		0.567
Institutions /Systems	22			0.630	0.613
	26			0.691	0.633
	27			0.652	0.615
	29			0.603	0.532

Table 2. Naming of constructs for social factor

Items	Constructs
15	Health and Safety practices
16	External social criteria
17	Local communities influence
23	Supporting educational
36	Decision influence potential
12	Research and Development
21	Service infrastructure
24	Regulatory and public services
25	Sensory stimuli
32	Partnership screens and standards
22	Mobility infrastructure
26	Security
27	Cultural properties
29	Grants and donations

Table 3. Environmental factor

	Item	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Chrobanch's alpha
Air	8	0.607						0.783
	9	0.787						0.836
	10	0.515						0.597
	21	0.576						0.527
Water	1		0.526					0.530
	5		0.623					0.704
	14		0.500					0.874
	18		0.800					0.816
Land	3			0.705				0.531
	13			0.670				0.779
	22			0.533				0.707
Materials	4				0.795			0.682
	15				0.555			0.641
	16				0.632			0.552
	17				0.594			-0.623
Mineral and Energy Resources	19					0.626		-0.666
	20					0.686		-0.608
Institutions/ Systems	6						0.599	0.623
	7						0.719	0.533
	12						0.525	0.517

Table 5 and Table 6 refers to the dimensions of economic factors and naming of the constructs. These benefits are considered as outputs and all the items coming under three pillars of SSCM (i.e. Social, Environmental and Economic factors) all together are considered as inputs of SSCM.

Relative importance of items and dimensions in the Sustainable Supply chain Management measuring instrument(Measurement of average scores of SSCM dimensions)

The value of average score represents the extent to which the respondents agree to the statement in the respective item of the questionnaire. For example the average value of item number 23 is calculated by taking total average of all 62 responses is 3.83. The details is as (4+5+4+5+5+5+4+4+3+4+4+4+3+3+4+5+2+4+5+5 +5+4+4+4+3+3+5+4+3+2+3+2+3+5+3+2+2+4+2+5+3+3+4+5+4+5+3+ 4+4+5+4+5+5+5+4+4+3+4+4+4+3+3) / 62 = 3.83

Table 4. Naming of constructs for environmental factor)

Items	Name of Constructs
8	Environmental identification
9	Environmental planning
10	Environmental assignment
21	Recyclability
1	Environmental practices
5	Process adoption
14	Consumption of raw material
18	Production of toxic products
3	End-of-pipe controls
13	Resource consumption
22	Environmental design
4	Pollution prevention
15	Consumption of water
16	Pollution production
17	Production of polluting agents
19	Production of waste
20	Post use
6	Environmental management
7	Environmental establishment
12	Environmental performance

The survey results plotted in Figure 1 show that the highest response of 3.83 has come for item number 21 and 23 that belongs to the dimension Workplace/Internal and Community/External. Whereas the lowest one is 3.37 for item number 29 and 24 belonging to the dimension Institutions /Systems and community/ external of economic performance. This confirms that the maximum people have agreed on item 21 and 23 that deals with the factors as Service infrastructure and educational support. On the other hand they have given the lowest response to item 29 and 24 which are related to the factor of Grants and donations and Regulatory and public services of the firms. This means that most of them are observed to have been dissatisfied with the expenses towards Grants and donations as well as Regulatory and public services. Similarly, items 15, 32 and 22 are other top scored items, while 25, 26, 27 and 36 are good scored items and 12, 16 and 17 are less scored items of the Social factors.

Table 5. Economic factor

	Item	Factor1	Factor2	Factor3	Facor4	Chrobanch's Alpha
Economic Performance	7	0.667				0.510
	8	0.876				0.581
	18	0.800				0.550
	24	0.500				0.573
	25	0.799				-0.534
	31	0.783				0.571
Financial Health	1		0.507			0.582
	2		0.825			-0.510
	3		0.765			0.691
	5		0.689			-0.557
	6		0.789			-0.528
	33					0.740
Market and Structure	30			0.695		0.594
	20			0.710		0.522
	21			0.695		0.531
	22			0.649		-0.526
	23			0.873		0.516
Institutions/ Systems	26				0.702	0.657
	28				0.698	-0.713
	34				0.774	0.824

The value of average score represents the extent to which the respondents agree to the statement in the respective item of the questionnaire. For example the average value of item number 16 is calculated by taking total average of all 62 responses is 3.82. The details is as

(4+5+5+5+5+4+5+5+3+5+4+1+3+4+3+3+ 3+ 3+ 4+ 4+ 5+ 4+ 4+ 3+ 4+ 3+ 2+ 4+ 5+ 3+ 4+ 2+ 5+ 5+ 1+ 3+ 4+ 2+ 4+ 5+ 5+ 5+ 2+ 1+ 5+ 5+ 4+ 4+ 5+ 4+ 5+ 2+ 5+ 4+ 1+ 2+ 5+ 4+ 5+ 2+ 4+ 5) **/** 62 = 3.82

The survey results plotted in Figure 2 show that the highest response of 3.82 has come for item number 16 that belongs to the dimension of Material. Whereas the lowest one is 3.29 for item number 8 belonging to the dimension air of economic performance. This confirms that the maximum people have agreed on item 16 that deals with the factor as Pollution production. On the other hand they have

Table 6. Naming of Economic constructs

Items	Name of Constructs
7	Less order fills lead time
8	High Order fill rate
18	Depth of supplier pool
24	High Cost investment on the project
25	High operating cost
31	Cost investment for waste treatment
1	Compliance with cost
2	Improvement in Cost reduction of output
3	Improvement in Product and process Quality
5	Innovativeness in process operation
6	New use of technologies
33	Cost investment for disposal of hazardous wastes
30	Reduce energy usage during production
20	Increase in Market share
21	Certified by Regulatory compliance (e.g. Consumer Product Safety Act)
22	Certified by ISO 9000 certification
23	Quality Management System in use, like TQM, KIZEN, POKA YOKA, JIT etc.
26	Achieve economic conditions
28	Investment for sustainability
36(34)	Engage in environmentally friendly disposal

Figure 1. Average score of social factor

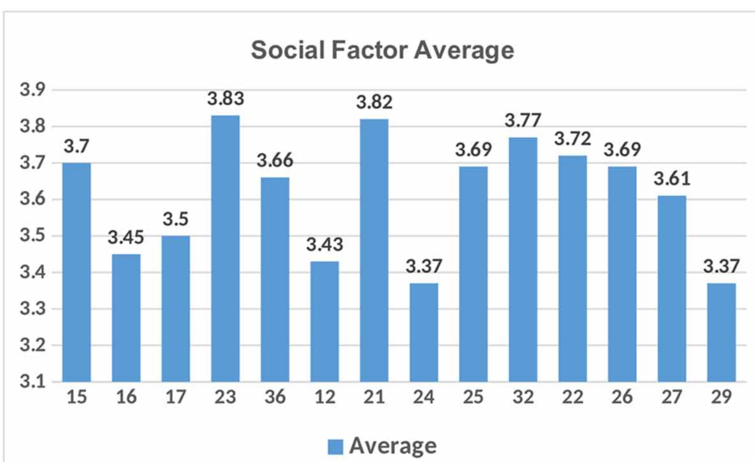
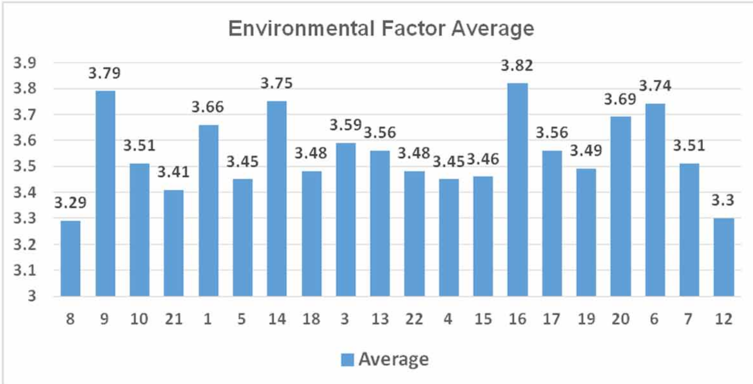


Figure 2. Average score of environmental factor



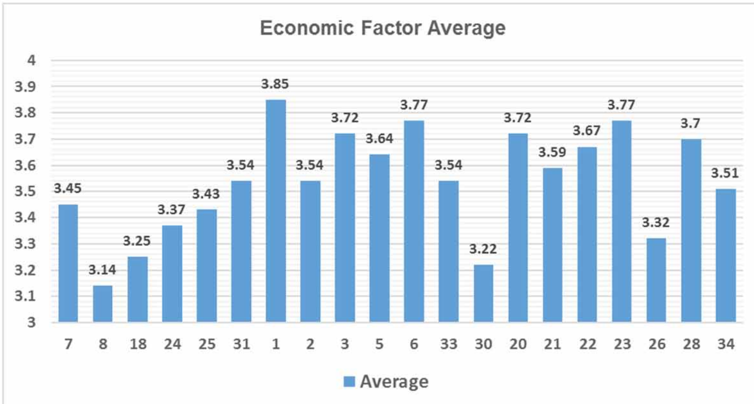
given the lowest response to item 8 which is related to the factor of Environmental identification. This means that most of them are observed to have been dissatisfied with the Environmental identification. Similarly, items 1, 6, 9, 14 and 20 are other top scored items, while 3, 7, 10, 13 and 17 are good scored items and 4, 5, 12, 15, 18, 19, 21 and 22 are less scored items of the Social factors.

The value of average score represents the extent to which the respondents agree to the statement in the respective item of the questionnaire. For example the average value of item number 1 is calculated by taking total average of all 62 responses is 3.85. The details is as

(4+3+5+5+4+4+5+5+4+4+5+4+5+4+5+5+5+4+4+5+2+1+3+5+4+3+3+
4+4+4+3+4+2+4+2+5+4+3+5+3+3+2+5+3+5+1+5+4+4+5+5+3+5+5+3
+4+2+5+2+4+5+2) / 62 = 3.85

The survey results plotted in Figure 3, show that the highest response of 3.85 has come for item number 1 that belongs to the dimension of financial health. Whereas the lowest one is 3.14 for item number 8 belonging to the dimension air of economic performance. This confirms that the maximum people have agreed on item 1 that deals with the factor as Compliance with cost. On the other hand they have given the lowest response to item 8 which is related to the factor of high order fill rate. This means that most of them are observed to have been dissatisfied with the high order fill rate. Similarly, items 3, 6, 20, 23 and 28 are other top scored items, while 2, 5, 21, 22, 31 and 33 are good scored items and 7, 18, 24, 25, 26 and 30 are less scored items of the Social factors.

Figure 3. Average score of economical factor



NETWORK PARAMETER

The back propagation module of a neural network package Neu Net Pro version 2.3 is used for the training and testing of survey data. The network parameters are taken as follows: Input layer with 34 nodes (all items of social, environmental and economic factors taken after factor analysis), one hidden layer with ten nodes and an output layer with a single node. A single question regarding overall customer satisfaction is considered as the output. Similarly for 8 outputs (benefits) of SSCM the similar process is followed.

Training of the network is stopped at this point. In order to find the robustness of the proposed model, sensitivity analysis was carried out. Sensitivity analysis is used to find out the impact of SSCM practices measurers on nine outputs or benefits achieved after implementations. The inputs in the test samples are varied one at a time systematically up and down ±10% from its base value holding other items at their original values. The scaled change in output is calculated with the current input increased by 10% and the current input decreased by 10%. The scaled change in output is given by: (Scaled output for 10% increase in output - Scaled output for 10% decrease in output)/2. Thus the results obtained are the scaled output change per 10% change in input. The calculation is repeated for level input and every fact and then averaged across all the facts yielding a single mean scaled change in output for each input criterion. Table. 7 shows the ANN prediction results of all measurand inputs (i.e. factors of SSCM) with output Customer satisfaction in SSCM. The result of Table 7 shows that items like 12, 21, 5, 2, 15 and 31 are common items of three factors Social, Environmental and Economic factors as all the outputs are showing negative scores.

Table 7. Measured indicators of SSCM with respect to Output for customer satisfaction

	Item	Run	Privatized	Nationalized	Imported
Workplace/ Internal	15	1 56945	-0.017	- 0 067	- 0.037
	16	156945	-0.076	0.350	0.168
	17	156945	0.125	0.119	0.164
	23	156945	0.124	0.057	0.031
	36	1 56945	0.430	0.087	-0.014
Community/ External	12	156945	-0.027	-0.183	-0.003
	21	156945	-0.007	-0.019	-0.013
	24	156945	0.011	0.007	0.002
	25	156945	0.003	0.005	0.010
	32	156945	0.008	0.012	0.021
Institutions / Systems	22	156945	0.035	0.015	0.026
	26	156945	-1.010	0.090	0.160
	27	156945	-0.179	-0.021	-0.023
	29	156945	0.032	0.078	0.019
Economic performance	7	157990	0.200	0.130	0.390
	8	157990	-0.620	-0.430	-0.290
	18	157990	0.480	1.230	-0.350
	24	157990	0.015	0.012	-0.100
	25	1 57990	0.205	-0.032	-0.050
	31	1 57990	-0.775	-0.21 5	-0.525
Financial health	1	157990	0.015	-0.082	0.010
	2	157990	-0.293	-0.3275	-0.535
	3	157990	0.256	1.l06	-0.019
	5	1 57990	0.115	-0.95	-0.7
	6	157990	-0.315	10.34	-0.13
	33	1 57990	-0.620	-0.43	-0.29
Market and structure	30	1 57990	0.480	1.23	-0.35
	20	157990	0.015	0.012	-0.1
	21	157990	0.205	-0.032	-0.05
	22	1 57990	0.131	0.57	1.03
	23	157990	1.010	-0.21	0.24
Institutions/ Systems	26	157990	-0.001	-0.23	-0.35
	28	157990	0.300	0.035	0.009
	36(34)	157990	-0.290	-0.860	-0.335

continued on following page

Table 7. Continued

	Item	Run	Privatized	Nationalized	Imported
Air	8	3105	-0.027	-0.030	-0.276
	9	3105	0.010	-0.080	0.395
	10	3105	0.610	-2.283	-0.340
	21	3105	1.700	-0.072	0.282
Water	1	3105	-3.080	-0.76	-0.510
	5	3105	-0.065	-0.260	-0.047
	14	3105	0.275	-0.125	0.275
	18	3105	-0.495	0.020	0.200
Land	3	3105	0.070	-4.500	0.205
	13	3105	-0.010	-0.080	-0.250
	22	3105	0.150	-0.005	-0.030
Materials	4	3105	-0.045	1.770	0.350
	15	3105	-0. 130	0.310	-0.050
	16	3105	-0.310	-0.276	-0.230
	17	3105	0.010	0.435	0.250
Mineral and energy resources	19	3105	-0.010	-0.080	-0.250
	20	3105	0.190	-0.105	-0.230
Institutions/ Systems	6	3105	-0.145	-0.670	0.334
	7	3105	-0.530	0.610	-0.150
	12	3105	-0.234	-0.216	-0.330

Table 8. For achieving Customer satisfaction improvement required

Sl. No.	Item	Customer's Need
1	15	Health and Safety practices
2	12	Research and Development
3	21	Service infrastructure
6	31	Cost investment for waste treatment
7	2	Improvement in cost reduction of output
8	5	Innovativeness in process operation

CONCLUSION

The growing attention for the research in the field of measures of sustainability performance in the supply chain in the last two decades depicts various proposed methods and analysis deals with conventional performance measurement of financial and operational criteria. Particularly in the most literature contributions only associated with evaluating negative impacts of conventional supply chains i.e. environmental and economic aspects. But the focus of this research is on TBL dimensions i.e. social Environmental and economic aspects in different kinds of supply chai ns and the importance of SCM is playing the role of transparency. This research work contributes to making awareness about the social and environmental complexities and relevance for economic view and supply chain management. Thus it is interested to achieve the developments of measurement and management of sustainability performance in supply chains as compared to simply traditional supply chains.In future some more work can be done for evaluating behaviourial aspects of SSCM. A common platform with a single voice for all shareholders and stake holders of the supply chain network is essential in order to transform these individual attempts into a comprehensive and collective movement. From literature review it is revealed that the improvement of sustainability performance measurement systems requires the integration of social, environmental and economic aspects. Hence a framework is explicitly suggested and factor analysis is done to evaluate the sustainable supply chain sustainability performance measurement system within triple bottom line dimensions.

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APPENDIX

Questionnaire of Economic Performance Indicators for Adopting SSCM

1 2 3 4 5

1. High Order fill rate
2. High Order fulfillment cost
3. Less Product defect rate of coal
4. Less Transportation cost per unit
5. High Productivity of plant
6. Market value of product
7. Better Profitability ratio / increase in organizational profits
8. Reliable cost of goods sold
9. Return on working capital
10. Degree of vertical integration
11. Depth of supplier pool
12. Breadth of customer base
13. Increase in Market share
14. Certified by Regulatory compliance (e.g. Consumer Product Safety Act)
15. Certified by ISO 9000 certification
16. Quality Management System in use like TQM, KIZEN, POKA YOKA, JIT etc.
17. High Cost investment on the project
18. High operating cost
19. Achieve economic conditions
20. Realized economic profits
21. Investment for sustainability
22. Cost Investment in IT for sustainability
23. Reduce energy usage during production
24. Cost investment for waste treatment
25. Cost paid as fine for environmental accidents
26. Cost investment for disposal of hazardous wastes
27. Engage in environmentally friendly disposal

Questionnaire of Social Performance Indicators for Adopting SSCM

1 2 3 4 5

1. Internal Social Criteria
2. Employment practices
3. Disciplinary and security
4. Employee contracts
5. Equity labor sources
6. Diversity
7. Discrimination
8. Flexible working arrangements
9. Job opportunities
10. Employment compensation
11. Research and Development
12. Career development
13. Health and Safety incidents
14. Health and Safety practices
15. External social criteria
16. Local communities influence
17. Health
18. Education
19. Housing
20. Service infrastructure
21. Mobility infrastructure
22. Supporting educational
23. Regulatory and public services
24. Sensory stimuli
25. Security
26. Cultural properties
27. Economic welfare and growth
28. Grants and donations
29. Contractual stakeholders
30. Procurement standard
31. Partnership screens and standards
32. Supporting community projects
33. Consumers education
34. Other stakeholders influence
35. Decision influence potential

36. Stakeholder empowerment
37. Collective audience

Questionnaire of Environmental Performance Indicators for Adopting SSCM

1. As Mine fill
2. As fill material in cement
3. Building Blocks
4. Light weight aggregates
5. Partial cement replacement
6. Road sub base
7. Grouting material
8. Filler in asphalt mix for roads
9. Partial replacement of lime aggregates in concrete works
10. Roads and Railways embankments
11. Land filling material
12. Manufacturing ash bricks
13. In agriculture depending on crops
14. Low lying land Wasteland development
15. Ash based brick making product units installation
16. Installation of Bio-methanation plant
17. Installation of facility for conversion of domestic waste to organic fertilizer
18. Installation of Vermi Composting for canteen waste
19. Segregation, storage and disposal of hazardous and non-hazardous waste into separate pits for healthy sanitation of township
20. Green Belts, Afforestation & Energy Plantation (Plantation of trees in around plants and townships)
21. Reclamation of Abandoned Ash pond
22. Ecological Monitoring & Scientific Studies
23. Environment Impact Assessment Studies
24. Socio-economic Studies
25. Ecological Monitoring Programme
26. Geo-hydrological Studies
27. Use of Waste Products & Service
28. Advanced / Eco-friendly Technologies like (IGCC)
29. Reduction in land requirements for main plant and ash disposal areas in newer units.
30. Capacity addition in old plants, within existing land

Chapter 14
Investigating the Impact of ERPs on Job Shop Manufacturing Logistics Performance

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ABSTRACT

Job shop manufacturing processes have been reluctant to adopt enterprise resource planning systems (ERPs) for enhancing logistics performance. The cost of adopting and deploying ERPs is a high-entry barrier. Prior research has claimed that performance can be enhanced by improving logistics planning using technology such as ERPs. Most past research has examined the effect of ERPs on logistics performance in production processes other than job shops, which seems to suggest that in small-scale production processes the cost of ERPs makes it irrelevant. Are manufacturing job shop production processes the exception that proves the rule? Using both a t-test two sample for means and a Kolmogorov-Simonov (KS) test, this study tested whether or not ERPs can improve supply chain logistics performance in job shop manufacturing processes. The results might lead to a positive social change in the adoption or non-adoption of ERPs in job shop manufacturing.

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INTRODUCTION

In today's highly competitive environment, companies that have not mastered the logistics dimension of the operations and strategic management will disappear. This statement is proven by the fact that 230 of the 500 leading companies in the world have disappeared in the past ten years; therefore, when it comes to the need to adapt over the time, every organization is concerned and none is invincible; companies that do not control the logistic managerial dimension of their management will disappear.

High-stake operations require high-performing logistics systems to set them up for success. ERPs can be a powerful tool for enhancing performance (Sun, Ni, & Lam, 2015). However, supply chain management (SCM) tools are the last mover among various industries (Kim & Kwon, 2015). Kathleen et al. (2005) found that the cost of adopting and deploying enterprise resource planning systems (ERPs) is a high-entry barrier and, to some extent, a leading reason for whether or not to adopt ERPs in job shops. The average total cost of an ERP ownership is $15 million, the lowest $400,000, and the highest $300 million (Meta Group, 2011; Stevenson, 2018). In addition, several hidden costs exist such as training, integration, testing, data conversion, data analysis, consultant fees, and post-ERP depression (Deloitte Consulting, 2010). The slam-dunk, franchising (phased), and big bang approaches are commonly used for implementing ERP systems.

According to Aslan, Stevenson, and Hendry (2012), by providing real-time data availability, ERPs can be useful for make-to-order organizations' manufacturing companies. It should be noted that job shops are among make-to-order organizations. However, several studies conducted by Kumar (2008, 2009), in consideration of potential benefits of packaging American hospitals' supply chains, failed to identify any significant benefits. A very small hospital (clinic) logistics system is in some ways similar to that of a manufacturing job shop. A job shop system is a small type of production system in which a low volume of high-variety goods or services is produced. Processing is, therefore, intermittent (Stevenson, 2018). Kumar's 2008 and 2009 studies reinforced the assumption that ERPs are not suitable or efficient for job shop manufacturing productions systems.

This article depicts a study conducted by the author and his research team. In this empirical study, direct observations and tests were conducted at a small US company that makes use of a job shop manufacturing process. The study's purpose was to test the effectiveness of ERPs on a job shop manufacturing process. In fact, from the system approach, every business function is vital for the achievement of the company's overall goals, which include leveraging resources in a cost-effective way to sustain the company's growth and, thus, to increase stakeholders' value.

The company under study designs and builds hand-tufted carpets for the airline industry. The company's production system is a job shop type, that is, a business operating on a relatively small scale. Today, its supply chain consists of a network of dying houses and carpet manufacturers located around the world. In 2012, its lead-time was more than three times the average in the industry, leading to a significant decline of market shares. The situation forced the company to lay off more than half its workforce. New supply chain partnerships were developed in an attempt to reduce the lead-time and improve the overall logistics system, but without success. Consequently, the firm was losing more customers. Two business audits pointed out logistics planning as the leading cause of the firm's poor performance. Many companies were facing (others are certainly experiencing) similar logistics-related issues. Prior research has claimed that performance can be enhanced by improving logistics planning using technology such as ERPs. However, were manufacturing job shop production processes the exception that proves the rule? The study tested whether even in job shop manufacturing ERPs can improve logistics performance.

Today's Market Logistics Challenges

In today's market, being able to deliver materials and products to manufacturers and end-users quickly and efficiently is crucial for keeping market shares and maximizing profits. The wide range of materials adds another layer of challenge to the logistics function. In fact, companies are now involved not only in the supply of raw materials, planning, and production of resources, tools, and spare parts, but also in the production of semi-finished, finished, and trading goods. Companies are also required to supply manufacturers with parts, maintenance assemblies, and operating supplies, as well as empties and returning packaging. Improving the quality and effectiveness of a company's logistics, therefore, is an important area to invest in. Production, as a result, can focus on determining the most effective bill of capacity, labor, resources, and operation to produce high quality products.

Distribution of Goods in a Globalized Economy

In general, companies are confronted with numerous problems, among which one of the most detrimental is their inability to position people, materials, and products where internal and external customers need them, primarily for the purpose of delivering quality products in the required quantity to the required place, not only at the lowest cost possible, but also by providing the level of predetermined service. Strategic leaders refer to this series of issues as logistical problems. The most visible point is the subcontract of activities such as packaging, labeling, storing, transporting, material handling in processing centers, and physically distributing the products.

Logistics effectiveness is not always at its highest potential, even when the logistics contracts are defined clearly with a higher level of precision. The logistics effectiveness can remain low, considering the broad scope of operations that firms generate to meet customers' needs. The situation has become more complex with the globalization of the economy; customers are now more demanding in terms of price, short delays, and quality products. Although countries have traded with each other for thousands of years, globalization's impact is greater today than ever before (Murphy & Wood, 2011). In today's economy, the demand for quality goods and services is coming from all over the world, and firms must at least meet customers' needs to survive; the best companies gain and sustain a competitive advantage over their rivals.

The Need for High-Performing Logistics Systems

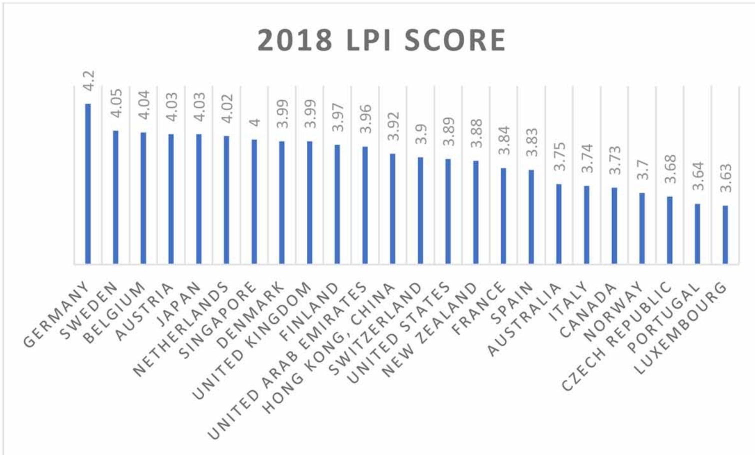
A high-performing logistics system provides effective customer service by delivering the product or service in the best condition, to the needed location, at a specific time, for the lowest possible cost. An effective logistics system should prevent stockouts and build customers' trust by developing the flexibility and ability to obtain internal or external resources that are necessary to adapt to changes in customers' preferences, needs, and demand, as well as the firm's chain of supply. In today's highly competitive environment, companies that would not have mastered the logistics dimension of operations and strategic management will disappear. High-stake operations require high-performing logistics systems to set them up for success.

Why Is the United States Logistics Performance Low?

Both domestic and international logistics performance indexes (LPIs) are among the most credible international measures of a country's overall logistics performance. The World Bank monitors and administers the LPI. According to the World Bank (2018), the LPI consists of both qualitative and quantitative measures and helps build profiles of logistics for countries. It measures performance along the logistics supply chain within a country and offers two different perspectives: international and domestic. The LPI 2018 allows for comparisons across 160 countries. As depicted in Figure 1, the United States ranked fourteenth, lagging behind countries such as Belgium, Japan, and China.

In the United States, in particular, companies operate in an environment with very sophisticated logistic infrastructures—roads are well maintained so that goods can flow within a city and across state lines. There is consistent electricity, internet

Figure 1. The 2018 logistics performance index (LPI)



access, telephone access, and a nearby airport. The question remains then: Why do firms miss delivery times even when uncontrollable variables such as the weather, government decisions, competitors' decisions, and support infrastructures do not constitute obstacles preventing them from achieving their logistic goals.

Based on managerial experience from many companies and discussions with other managers around the world, the logistical system's planning seems to play an important role in the success of supply chains, as does the logistical system's delivery component. However, the question is: Does improving the planning of the logistical systems using ERPs affect logistics effectiveness in a job shop setting?

This section discussed the distribution of goods in a globalized economy and the need for high-performing logistics systems in general. The next section will review the existing literature.

LITERATURE REVIEW

This section presents a review of the literature related to the effectiveness of logistics management. First, the state of research on the effectiveness of logistics is introduced. Second, effective management practices are examined. Third, one basic function of effective logistics management—logistics planning—is examined and the integration of effective logistics within and across the entire supply chain is discussed.

Business Research on Effective Logistics

Logistics Migration to Business Through Marketing.

The term logistics migrated to the business sector through marketing (Russell, 2000). In 1948, the American Marketing Association defined logistics as the movement and handling of goods from the point of production to the point of consumption or use (Robeson & Copacino, 1994). This application of logistics in the business sector represented a move to apply military principles to the distribution of goods (Russell, 2000). Consequently, a new academic field—business logistics—emerged.

Business Logistics and Studies in the Field

The conceptual model of business logistics refers to the construct as material management and physical distribution (Murphy & Wood, 2011). Nevertheless, in his research, Russell (2000) views effective logistics in a broader sense. He explains that effective business logistics include the planning and management of supply sources, inventories, transportation, distribution networks, and related activities, and supporting information to meet customers' requirements. The definition provides more details about business logistics than Murphy and Wood's definition.

Logistics Capabilities

Logistics capabilities include physical assets such as buildings, plants, factories, manufacturing centers, processing centers, distribution centers, and warehouses; utilities; human resources; computers and transportation vehicles, including, cars, trucks, trains, aircrafts, and ships; materials and goods; and supporting information.

Logistics Protocols

The most perceivable activities of a logistics protocol is the sequence of its deployment. Protocols include operational plans, methods, logic networks, data systems, strategies for running effective logistics, logistics decision-making processes and techniques, outsourcing strategies, and design and implementation of contingency plans for forward and reverse logistics (Russell, 2000).

Logistics as a Science

Russell concluded his study by affirming that logistics is a science, the science of developing and managing the capabilities and protocols responsive to customer-driven service requirements.

The Concept of Management and Studies on Logistics Effectiveness

According to Robbins and Coulter (2017), the first published research on management was *The Wealth of Nations* by Adam Smith in 1776. Smith promoted the economic advantages that organizations and nations could gain by using the division of labor, also known as job specialization. During the Industrial Revolution, which began about 1750, innovative technology such as machine power substituted for human power, increasing productivity. Production moved from homes to factories. New technologies triggered the emergence of large, efficient factories that needed people who could efficiently and effectively forecast the demand for goods as well as plan and distribute goods. However, formal theories were needed to guide managers in running the new large organizations (factories) generated by the new technology. The first studies appeared in the early 1900s (Robbins & Coulter, 2017). It should be noted that before formal management theory existed, thought and practice emerged with a certain degree of formality.

Logistics Management and its Performance

The Council of Supply Chain Management Professionals (CSCMP) defines logistics management as the part of supply chain management that plans, implements, and controls the efficient and effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers' expectations and needs. Logistics management includes material management, which is defined as the movement and storage of materials into a firm (Murphy & Wood, 2011). Material handling is considered the short distance movement of materials between two or more points. Physical distribution is movement from the firm's warehouses to processing and distribution centers, retailers, and end users. A wide range of literature exists on logistics, but little on logistics management. At this point, to my knowledge, no specific study on the effectiveness of logistics management exists.

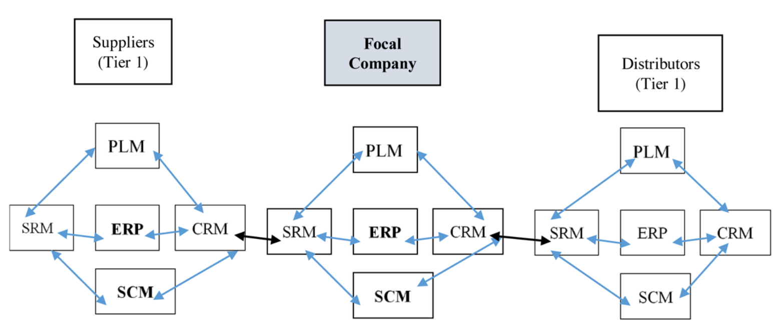
ERPs Integration with Supply Chain Management and Logistics

ERPs, the third generation of enterprise systems (ESs), began with material requirements planning (MRP) in 1964. This was followed by manufacturing resource planning (MRP II) in 1983. ERPs are currently the most complex version of ESs to integrate both the functional and cross-functional processes in the organization. ERPs have MRP as their core system. ERPs support all business function operations and transactions, linking them in a uniform platform to make information available in real-time across the organization's entire supply chain. ERPs track the information within and across organizations. The internet provides broad visibility for the information. Supply chain managers utilize information provided by ERPs as the basis for making informed decisions.

A close look at an ES application suite reveals the need to integrate ERPs with SCM software. As depicted in Figure 2, the five basic components of a simple ES are the product life cycle management (PLM), the supplier relationship management (SRM), the ERP, the SCM, and the customer relationship management (CRM). ERPs are the epicenter of ESs because they integrate and connect the other ES components.

ERP systems are configurable ESs designed to integrate processes and information within and across organizations (Kumar & Van Hillegersberg, 2000). ERPs allow organizations to automate repetitive tasks, underlining transactions and processes. If properly used, SCM can be improved by integrating ERPs. The organizations best placed to succeed have implemented an adequate business infrastructure utilizing ERP capabilities (Srinivasan, 2010). ERPs help to increase velocity in the supply chain fulfillment process.

Figure 2. Enterprise application suite in the supply chain (Source: Essila, 2018)



ERP Systems' Effectiveness on Logistics Performance

A study by Ali and Miller (2017) supported the findings that approximatively 66 to 70 percent of ERP systems projects failed to deliver on the objectives (Lewis, 2001, Carlo, 2002, Shores, 2005, Ward et al. 2005, Zabject et al., 2009, Sun et al. 2015, Ali & Miller, 2017). The literature on ERP systems effectiveness can be classified into seven areas (Powell, 2013). These areas include ERPs as enablers for competitive advantage, their modes of implementation, the support functionality, their role and value of information, the supply chain integration, the development of Kanban, and the role of Internet. This study falls into the supply chain integration as it pertains to the logistics performance. In fact, the integration of ERPs into supply chain management is related to the role and value of the information for logistics performance. Based on a random sample of 186 ERPs implementations, a study by Hendricks et al. (2007) found significant statistical evidence supporting the hypothesis that ERPs improve performance and profitability in medium-size business and large enterprises by replacing ineffective manual interfaces between systems with cross-functional transaction automation. ERPs enable order cycle and customer response time reduction and improve to achieve a competitive advantage (Bayou & de Korvin, 2008). Most studies used the Esteves and Bohórquez (2007) and Esteves (2009) classification based on ERP lifecycle framework for assessing effectiveness and conducting systematic literature reviews on ERPs. Understanding the dynamics of e-SCM performance drivers and their integration with ERPs, along with their accompanying challenges, becomes a necessity (Essila, 2018).

Summary

Although numerous studies have been conducted on logistics management and ERPs' impact on logistics performance, this review shows that little research has addressed the effectiveness of logistics management as its relates to ERPs in job shop manufacturing processes.

Most of the studies focused primarily either on logistics performance or ERPs' implementation effectiveness in medium-size businesses and large enterprises but not in small-scale environments such as a job shop. In addition, no study was found on the impact of ERPs on job shop logistics performance.

METHODOLOGY

Hypothesis

The study tested the following hypotheses:

H_0: The use of logistics planning techniques and technology, such as ERPs, has no effect on logistics management effectiveness in a job shop system.
H_A: The use of logistics planning techniques and technology, such as ERPs, has an effect on logistics management effectiveness in a job shop system.

Thesis Statement

The research team predicted that the dependent variable of effectiveness of job shop logistics performance was influenced by one independent variable—the effective use of ERPs. The two variables (independent and dependent) were related as explained below.

Logistics planning technologies, namely ERPs, influence the execution of logistics activities. For instance, it was more time-consuming to determine the quantity on hand manually each time the company had to provide a delivery date to a customer. The use of an ERP software, such as system applications and products in data processing (SAP), allows an employee to obtain information about thousands of products in real time and faster than without the software because the software can integrate many business areas that together follow the movement of materials and goods from the firm's suppliers to the consumers. In sum, the use ERPs could significantly influence the effectiveness of business logistics management performance even in a job shop setting. Since the study's purpose was identified, the research team could further clarify the issue to be solved.

The Setting and Time Period of Data

The study was conducted in its natural environment (the floor factory). The data were collected from 2013 to 2015. Although some causal aspects were explored, the study's timespan was not long enough to attempt to establish a truer causation that might require a real manipulation of certain variables to study the effect of such manipulation on the dependent variable of interest. Such a study would also have required a moderate and even excessive interference that might lead to a contrived study setting.

The research team set performance standards along with measures and key performance indicators (KPIs); it continuously measured the current actual performance based on KPIs, trained the workforce, and had it perform over a six-month to one-year period, reassessed actual performance, and compared the results against the same standards for the previous corresponding time period).

Data Collection and Analysis

Sources of data collection were individuals in the logistics department (subgroup, one unit), focus groups, and unobtrusive measures such as the firm records, the level of business efficiency, and other data. Although those trace measures originate from a primary source that did not involve people, their use was important for the study. Other methods of data collection were interviews, observations, and data from the company's information system, including weekly, monthly, and annual reports. The unit of analysis for this study was the company's logistics department. Units of analysis are the primary components being analyzed in the study.

The second step in the study was to examine the relationship between the use of ERPs and the effectiveness of business logistic management performance, especially the planning function. On this aspect of the correlational study, the research team also collected data from employees and external consultants working on the project to indicate how employees used ERPs and to what extent the firm experienced success or failure in its logistics business functional area compared to when the firm did not use ERPs.

Since the problem statement was related to group effectiveness, the unit of analysis was at the group level. In other words, although the research team was gathering relevant data from all individuals comprising the logistics department and external consultants involved, the team aggregated the individual data into group data. According to Sekaran and Bougie (2013), the unit of analysis is the level of aggregation of the data collected during data analysis. It should be noted that the employees in the logistics department and external consultants were treated as one unit and the department was the unit of analysis since data was aggregated at that level.

Several procedures were used to acquire empirical evidence and analyze it in relation to answering the research questions. Among secondary data were monthly key performance indicators designed to monitor the logistics system. In addition to secondary data from other sources, a questionnaire was designed to collect primary data using a Likert-type rating scale to measure the underlying construct of interest—effectiveness of logistics management, the dependent variable in this study.

Kolmogorov-Simonov (KS) Test

In this correlational study, a Kolmogorov-Simonov (KS) test was used for hypothesis testing with a minimal statistical significance of 5 percent. Prior to initiating the study measures, the protocols and processes were tested with a pilot group that mirrored the demographic makeup of the actual study's participants. Through data collected from the pilot test, the research group was able to make appropriate modifications to measures, processes, and protocols.

To ensure reliability and validity, the research team conducted a test-retest, parallel forms, and a Pearson Correlation coefficient to determine how consistently each item measured the effectiveness of logistics management for internal consistency in that particular business setting.

The data collected used a non-parametric testing method. The research team chose a KS-test because it tests the fit for ordinal measurement-scaled data. The KS-test required a comparison of the expected cumulative distribution function under the null hypothesis. For the purpose of this study, the study group designated $Fo\left(X\right)$ as the expected cumulative distribution function and $Sn\left(X\right)$ as the observed cumulative distribution function. The absolute difference between the expected cumulative proportion and the observed cumulative proportion is given by *D*:

$$D = max\left|Fo\left(x\right) - Sn\left(x\right)\right|$$

For the purpose of the KS-test, in this case, the null hypothesis is that respondents would equally prefer all categories of responses. The alternative hypothesis is that respondents did not equally prefer them. If the observed calculated D exceeded the critical D value, then the null hypothesis would be rejected. This leads to the conclusion that respondents did not equally prefer all items. The result then showed a significant choice for one item. The research team could have used the chi-square test of fit testing hypothesis instead of the KS-test, but it decided to use the KS-test because of its ease of computation. The KS-test also does not have the problem of minimum frequency in each cell as the chi-square test does. In addition, the sample was small and better suited to the KS-test.

RESULTS AND CONCLUSION

Results Related to Reliability and Validity

The group computed several types of reliability tests, including a test-retest reliability test to measure the stability after administering the same test at two different times to the same group of participants. A correlation coefficient of 0.83 was found. The inter-rater reliability resulted in 92 percent agreement after administering two different forms of the same test to the same group of participants. The reliability test was performed to measure the equivalence using the parallel forms. The two sets of scores were tested to gauge the correlation with each other. Testing the correlation with each other was also made to eliminate the influence of practice effects on participants' scores. The internal reliability test resulted in a Cronbach's alpha of .87. The internal reliability helped to determine how unified the items were in the questionnaire. The study group then collated performance on each item in the test with the total on the test that took a form of correlation coefficient usually referred to as Cronbach's alpha.

Results of the Hypothesis Test

For the purposes of a KS test, a D value was computed for each item. Items 1 (incomplete deliveries), 2 (easiness), 3 (value), 4 (satisfaction), 5 (frustration), 6 (responsiveness), 7 (incoming-shipment), 8 (out-going shipment), 9 (stock-outs), and 10 (challenge) of the test, respectively, resulted in the calculated D value of 0.3571, 0.442, 0.333, 0.2761, 0.3285, 0.3571, 0.3000, 0.3857, 0.358, and 0.2714. It should be noted that the test involves comparing the expected cumulative distribution function under the null hypothesis. Table 1 provides a summary of the results of the Hypothesis test.

Results of the Comparative Analysis of Performance Before and after ERP Implementation and Training

In addition to the hypothesis test, the result from the company's key performance indicators (KPIs) dashboard corroborated with the hypothesis test results. A summary of the results are shown in Table 2 and Figure 3. The t-Test (paired sample for means) result was statistically significant ($p < 0.023$) at a significance level of 5%.

The comparative analysis of the hard data from the company's annual key performance indicators (KPIs) indicated improvement as follows: The indicators were Items 1 (incomplete deliveries), 2 (unplanned deliveries), 3 (missed incoming deliveries), 4 (missed outgoing deliveries), 5 (customer logistics claims), 6 (non-

Table 1. Summary of the results of the hypothesis test.

Item	Description	Calculated D value
1	Incomplete deliveries	0.3571
2	Easiness	0.442
3	Value	0.333
4	Satisfaction	0.2761
5	Frustration	0.3285
6	Responsiveness	0.3571
7	Incoming shipment	0.3000
8	Out-going shipment	0.3857
9	Stock-out	0.358
10	Challenge	0.2714

Table 2. Comparison of logistics performance before and after training

Items	After (Year average)	Before (Year average)
Incomplete deliveries	3	9
Unplanned deliveries	5	8
Missed incoming deliveries	4	7
Missed outgoing deliveries	6	7
Customers logistics claims	7	6
Non-authorized partial deliveries	8	3
Returns due to logistics errors	6	3
System downs	7	4
Stock-outs	4	9
Wrong deliveries	5	8

authorized partial deliveries), 7 (returns due to logistics errors), 8 (system downs), 9 (stock-outs), and 10 (wrong deliveries) of the KPIs' dashboard.

In Figure 3, the full-line curve represents performance before and the discontinued curve line represents performance after. As depicted in Figure 3, the number of incomplete deliveries dropped from 9 to 3, the number of unplanned deliveries dropped from 8 to 2, the number of missed incoming deliveries dropped from 7 to 3, the number of customer logistics complaints increased from 6 to 7, the number

Figure 3. Comparison of logistics performance before (blue) and after (orange) training

of non-authorized partial deliveries increased from 6 to 8, the number of returns due to logistics errors increased from 3 to 7, the number of stockouts dropped from 9 to 4, and the number of wrong deliveries dropped from 8 to 5. Table 2 provides a summary.

SUMMARY OF RESULTS

This section presented the description derived from data, document analysis, and the interviews, which were compiled and structured in accordance with the research question. A wide picture of demographic data was provided along with reliability and validity results. The next section will outline the discussion, conclusions, implications for business logistics management practices, and implications for developing an appropriate measure of logistics management effective for better and improved logistics systems in both business and not-for-profit organizations.

Overview of the Population and Sampling Method

The population was composed of employees from the organization. A random sampling strategy was used to draw a sample from the population of about 40 employees. The sample consisted of 35 employees who ranged in age from 20 to 60, with a mean age of 42.9. The 35 employees working at the company consisted of 5 females and 30 males.

Explanation of Findings

Thirty-five adults were asked to rate different components of the effectiveness of the company's logistics system along a six-point rating scale.

Items 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 of the test, respectively, resulted in the calculated *d* value of 0.3571, 0.442, 0.333, 0.2761, 0.3285, 0.3571, 0.3000, 0.3857, 0.3572 and 0.2714 (see Table 1).

Hypothesis Test

The test involved comparing the expected cumulative distribution function of each item by measuring each component of the logistics effectiveness under the null hypothesis, being true to that of observed cumulative distribution function. Because the calculated *d* value of each item exceeds the critical *d* value (0.2100), the null hypothesis is rejected at 5 percent level. It should be noted that the critical *d* value for a significance level of 5 percent is 0.2100 for a sample of thirty-five. The results showed a significant preference for *agree* and *slightly agree* on the rating scale. An additional test was conducted using an IBM SPSS and automatically comparing observed data to hypothesized, using the binomial test, chi-square test, or KS test. The test chosen by the software package varies based on the data. The alpha values on the chi-square test were respectively: .002, .00, .006, .00, .005, 001, .00, .00, .015, and .014, rejecting the null hypothesis at the significance level of 5 percent. Table 3 shows a summary of results on Chi-square test.

Table 3. Alpha values on the chi-square test

Item	Description	Alpha Value
1	Incomplete deliveries	0.002
2	Easiness	0.00
3	Value	0.006
4	Satisfaction	0.00
5	Frustration	0.005
6	Responsiveness	0.001
7	Incoming shipment	0.00
8	Out-going shipment	0.00
9	Stock-out	0.015
10	Challenge	0.014

CONCLUSION

Conclusions resulting from this study occurred in two areas: (1) conclusions related to the results of reliability and validity; and (2) conclusions related to tests results. The research team computed several types of reliability tests, including test-retest reliability to measure the stability after administering the same test at two different times to the same group of participants. A correlation coefficient of .83 was found. The inter-rater reliability resulted in 92 percent agreement after administering two different forms of the same test to the same group of participants. This was performed to measure equivalence using parallel forms. The two sets of scores were tested to gauge their correlation with each other. This test was also made to eliminate the influence of practice effects on participants' scores. The internal reliability test resulted in a Cronbach's alpha of .81. The internal reliability helped the researchers determine how unified the items were in the questionnaire. The study group then collated performance on each item in the test with the total on the test, which took the form of a correlation coefficient usually referred to as Cronbach's alpha.

The first conclusion in the area of effectiveness of logistics management is that the use of technology does affect a logistics system's effectiveness even in a customized job shop manufacturing system. From the data collected for the purpose of a KS test, a *d* value was computed for each item. Items 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 of the test respectively resulted in the calculated *d* value of 0.3571, 0.442, 0.333, 0.2761, 0.3285, 0.3571, 0.3000, 0.3857, 0.3572, and 0.2714 (See Table 1).

It should be noted that the test involved comparing the expected cumulative distribution function under the null hypothesis being true to that of the observed cumulative distribution function. As a result, all observed *d* values exceeded the critical *d* values, therefore, rejecting the null hypothesis and supporting the hypothesis that logistics planning techniques and technology are associated with improved effectiveness of logistics management. It was, therefore, at the level of confidence of 5 percent that the use of logistics planning techniques and technology affect the effectiveness of business logistics management and that a correlation exists between the adoption and use of the aforementioned techniques and the effectiveness of the logistics systems.

The second conclusion is that a correlation exists between the use of technology and the improvement of logistics performance in a job-shop manufacturing system. The two data sets exhibited a high negative correlation between the logistics performance before the implementation of new ERP and the performance after their adoption and use. A .81 Pearson correlation coefficient was found when comparing the two data sets.

IMPLICATIONS FOR MANAGEMENT PRACTICE

Organizations, especially manufacturing companies, often face challenges related to the management of their logistics systems. To be effective, organizations need well-planned, organized, and controlled logistics systems. Planning using ERPs was the heart of the group's research, with more emphasis on factors that account for the planning of an effective logistics system using ERPs. In the light of the findings, the use of ERPs, if well used, can significantly improve the effectiveness of the logistics system even in specific environments such as customized job shops. The KS test rejected the null hypothesis along with other tests performed at a significance level of 5 percent. Yet because of the link between employees' skills and the proper use of ERPs, the techniques explored were more likely to provide a greater improvement when used by high-skilled professionals with the ability to work well with other group members as a team. A negative correlation between data in the time before the implementation of the new ERP system and the results a year after the migration provided an explanation of the phenomenon scrutinized, which was the link between the improvement of the logistics system and the adoption, acceptance, and use of the logistics information system.

REFLECTING UPON THE STUDY

Logistics capabilities, protocols, and principles can play a major role in the success of organizations around the world. This study suggests that capability is a cornerstone of the effectiveness of logistics systems. Although customized job shops require specific logistics management techniques that are somewhat different from traditional protocols, management still puts more emphasis on logistics planning because logistics planning using technologies such ERPs helps to establish strategies to achieve productivity gains and enhance the company's ability to generate more revenue while increasing profit and responsiveness.

LIMITATION AND DIRECTION FOR FUTURE RESEARCH

This study found ERPs relevant to the performance of a logistics system specific to a customized job shop manufacturing system. A point of caution remains concerning the waste that an application of logistics protocols can generate due to its operational requirements in terms of transportation, storage, distribution, and management of returns when executing a reverse logistics system. Recalls are a good example of such costly operations. Effective logistics management using ERPs also calls for adoption of continuous improvement principles and practices and the implementation of measurement tools. Any organization's success depends on knowledge, skills, and creativity that can be channeled into innovation when employees are highly motivated to meet and even exceed customers' requirements, resulting in a substantial value added to the whole community of stakeholders.

The study raised additional questions that can be best answered through the benefit of more research in the field and, in particular, the logistics management component of the business. A similar study with longitudinal design that would allow a moderate or even excessive interference with a purpose of establishing a more elaborate causal relationship will certainly provide more insights into the underlying construct. A longitudinal field experiment on the subject would also derive more detailed information about the effectiveness of logistics systems in job-shop environments.

Research could also be directed toward testing the hypothesis about the quality of technology used in logistics planning and its effect on logistics responsiveness. For instance, what factors influence whether or not the logistics professionals at the job level take pride and enjoy or dislike the full use of technological logistics capability? Is an entire automated logistics system possible, and would it be more effective? Research could look with detail into traditional logistics systems and technologically assisted logistics systems to elaborate a classification of technologically assisted logistics systems with a measure of the extent or magnitude of the technology involved.

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