DOKUZ EYLÜL UNIVERSITY
GRADUATE SCHOOL OF SOCIAL SCIENCES
DEPARTMENT OF BUSINESS ADMINISTRATION
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DOCTORAL THESIS

Doctor of Philosophy (PhD)

SUPPLY CHAIN AND THE EFFECTS OF INFORMATION TECHNOLOGIES ON SUPPLY CHAIN PERFORMANCE

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APPROVAL PAGE

DECLARATION

I hereby declare that this doctoral thesis titled as "Supply Chain and the Effects of Information Technologies on Supply Chain Performance" has been written by myself in accordance with the academic rules and ethical conduct. I also declare that all materials benefited in this thesis consist of the mentioned resources in the reference list. I verify all these with my honor.

20/06/2022

Sezai BAHAR

ABSTRACT

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Organizations today strive for a competitive advantage, but the actual competition occurs in the supply chain, where they engage. As a result, supply chain management and logistics operations for all partners in the supply chain should be coordinated through a more organized structure. Information technologies are becoming increasingly vital as supply chain operations and logistical routines become more sophisticated and integrated. Today's firms, in particular, are paying greater attention to their systems in order to keep their supply chain components connected and develop better and longer interactions. As a result of information systems, companies can easily plan, implement, and control supply chains and logistics operations. Information technology also allows organizations to save time and money. By delivering services, they can enhance customer satisfaction. Following the Covid 19 pandemic, the world has experienced an economic downturn and a reduction in foreign trade activity, which has heightened the importance of supply chain management. Companies were highly scrutinized in terms of their information technology capacity as well as their transportation competency during the quarantine period. The Analytical Hierarchy Process (AHP) method was used to examine how information technologies impact on supply chain performance and logistics operations before and after the Covid 19 period in this study. By using AHP method, the study's main and sub criteria were determined.

Keywords: Analytical Hierarchy Process (AHP): Supply Chain, Logistics, Information Technologies, Logistics 4.0, Digital Supply Chain

ÖZET

Doktora Tezi

Tedarik Zinciri ve Bilgi Sistemlerinin Tedarik Zinciri Performansına Etkileri

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İngilizce İşletme Anabilim Dalı

İngilizce İşletme Yönetimi Programı

Günümüzde organizasyonlar her zaman rekabet avantajı elde etmeye çalışmaktadır, ancak gerçek rekabet dahil oldukları tedarik zincirinde ortaya çıkmaktadır. Bu sebeple hem tedarik zinciri yönetimi hem de lojistik operasyonları tedarik zincirine dahil olan zincir bileşenleri tarafından daha sistemli bir ağ kapsamında ele alınmalıdır. Özellikle bilgi teknolojilerinin önemi her geçen gün daha kritik bir hal almaktadır, bunun sebeplerinden birisi de tedarik zinciri içerisindeki süreçlerin ve lojistik operasyonların hem daha karmaşık bir hal alması hem de tüm olguların birbirine entegre olmuş bir şekilde oluşturulmasıdır. Organizasyonlar bu süreç dahilinde elindeki teknolojileri geliştirme yoluna giderek tedarik zinciri yapılarını bir arada kenetlemek için kuvvetli ve uzun dönemli bir bağ kurma eğilimi içerisinde olmuşlardır. Bu sebeptendir ki organizasyonlar sahip oldukları bilgi teknolojileri ile lojistik operasyonlarını ve tedarik zinciri yapılarını planlamasını, kontrol etme süreçlerini ve yürütmesini daha akıcı bir şekilde oluşturabilmektedirler. Bunun yanı sıra zamandan tasarruf ve karlılık düzeylerini arttırması bilgi teknolojilerinin organizasyonlara sağladığı bir başka önemli katkılardır. Bu katkıların sayesinde hizmet kalitelerini ve müşteri hizmet değerlerini arttırabilmektedirler. Covid 19 salgının oluşturduğu ekonomik kriz ortamı uluslararası ticareti derinden etkilemiş ve bu durum organizasyonların tedarik zinciri performanslarına yansımış olup, buradaki faaliyetlerin öneminin daha da farkına varmalarına sebep olmuştur. Özellikle salgının yoğun olarak yaşandığı dönemlerde organizasyonlar gerek ulaştırma kapasitelerine gerekse de bilgi teknolojilerinin yeterliliklerine çok fazla önem vermişlerdir. Bu çalışma kapsamında Analitik Hiyerarşi Süreci (AHS) yöntemi kullanılarak bilgi teknolojilerinin tedarik zinciri üzerindeki etkileri

bulunmaya çalışılmıştır. Çalışmanın hem ana kriterleri hem de ara kriterleri AHS yöntemi ile hesaplanmaya çalışılmıştır.

Anahtar Kelimeler: Analitik Hiyerarşi Süreci (AHS): Tedarik Zinciri, Lojistik, Bilgi Teknolojileri, Lojistik 4.0, Akıllı Tedarik Zinciri

SUPPLY CHAIN and the EFFECTS of INFORMATION TECHNOLOGIES on SUPPLY CHAIN PERFORMANCE

CONTENTS

CHAPTER TWO

INFORMATION TECHNOLOGIES AND THE EFFECTS ON SUPPLY CHAIN MANAGEMENT

CHAPTER THREE

METHODOLOGICAL FRAMEWORK

ABBREVIATIONS

SC	Supply Chain
SCM	Supply Chain Management
IT	Information Technologies
IS	Information Systems
AHP	Analytical Hierarchy Process
SCOR	Supply Chain Operations Reference
CRM	Customer Relationship Management
EDI	Electronic Data Interchange
MRP	Material Requirements Planning
ERP	Enterprise Resource Planning
WMS	Warehouse Management System
RFID	Radio Frequency Identification
OMS	Order Management System
EDI	Electronic Data Interchange
TMS	Transportation Management System
VTS	Vehicle Tracking System
MRP	Material Requirements Planning
GPS	Global Positioning System
GIS	Geographic Information System
CPFR	Collaborative Planning Forecast Replenishment
VMI	Vendor Management Inventory
QR	Quick Response
POS	Point of sale
SSC	Smart Supply Chain
DSC	Digital Supply Chain
IoT	Internet of Things
CPS	Cyber-Physical Systems
SME	Small and Medium Enterprise

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

Today, companies try to continue their production in a growing competitive environment where they need to provide high quality goods and services to their customers. By this means, companies try to find out the ways how they can use their resources more efficiently. Within this economic system, companies try to have a competitive advantage and try to increase their market share. Therefore, they try to build solid relationships with their customers and suppliers in terms of providing value-added services. As a result of the collaboration with their business partners or suppliers, they can take the advantages on the processes such as improving their product quality, reducing the cost of the products or services, having more flexibility on their operations, and ensuring the customer satisfaction

In the global markets, it is important for companies to fulfill the market demands on time. Companies need to use their resources more efficiently as they want to be more competitive. Within this context, companies need to control the costs of their products. It should be always priority for the companies to improve their financial aspects and performance indicators. However, it is not always possible for them to reach their objectives on performance points in order to enhance the internal business processes. Hence, companies can follow one of the turning points – Information Technologies (IT) and Information Systems (IS) – for improving their Supply Chain (SC) performances. In this sense, it is significant that companies will be more effective and efficient if they choose correct technology and systems for their operations.

As the world becomes more global, companies keep up with the new aspects of the economic dimensions around them. Companies can plan their products' design in one country, they can provide their raw materials or components from another country, and they can also manufacture their products in a different country. At last, they serve their finished products in the foreign markets. Within such dynamic business environment, providing the services from other sectors shows us the importance of SC and logistics activities. Because of the significance of Supply Chain Management (SCM) and logistics activities, manufacturers, wholesalers, distributors, transporters, retailers, and customers are gathered in a network where they can fulfill their requirements. They need solid communication standards, because by having

strong coordination, the SC integration that they have will be more beneficial. Thus, they take common decisions on the issues such as production, inventory, and transportation with their partners.

With the transition from the industrial society to information society, the advanced technologies provide so many innovations for not only many sectors but also for the lives of the people. Particularly, the developments on both communication and transportation provide better standards for societies and organizations, by this way, flow of information, flow of product and flow of cash have become easier in any part of the globe. Notedly, IT construct the procedures from supplier to end user effectively and efficiently.

Most of the recent studies about SCM concepts focus on the subjects such as sustainability, SCM performance indicators, or SCM design, yet in this study, it is analyzed the SCM performance in terms of technological aspects, especially the significance levels of information in companies' business operations.

Selecting IT is one of the significant decisions for the companies' success in the sector. Determining the most suitable IT for businesses is one of the significant multi criteria decision making problem that contains both numerical and non-numerical criteria.

The objective of this study is to find out IT selection decisions of organizations and how it effects the performances of organizations' supply chain processes. IT selection process is analyzed with Analytical Hierarchy Process (AHP) method because both qualitative and quantitative data is not applicable with dimensional matrixes. After building a concept map, criteria were determined for the effects of IT on SC performances from deep interview study and various academics. Thus, in the study, first the questionnaire is given to the company executives about the IT that they use in their logistics or SC processes, or the technologies that they mutually use with their supply chain partners. In accordance with the responses taken by those questions, it is aimed to find out the methods for improving their IT systems on their SC process. By the end of the interviews, the obtained criteria are analyzed by using AHP method which is an important tool for dealing with complex decision making, and it aims to aid for the company executives to set the priorities and find the best decision. After by capturing both subjective and objective aspects of a decision, it is important to

determine the best criteria from the interviews as the AHP reduces the complex decisions to a series of pairwise comparisons, and then synthesizing the results. It is also implemented purposeful sampling method by asking the respondents open ended questions for obtaining more information about the sector's future or business segments.

The other objective of the study is that some of the interviews were able to be conducted with the company executives during Covid-19 outbreak, and it was also asked them to evaluate their business processes. It is discussed how their business phases were/are affected during the pandemic period. Moreover, during the interviews it is asked how their IT applications work on their SC or logistics operations after Covid-19 outbreak. At the end of the interviews, purposeful sampling is implemented by asking the respondents open ended questions for obtaining more information about the sector's future or business segments.

In the two chapters of the study, the conceptual framework of SC and IT on SC are provided with detailed literature review. In the last chapter, the aim and objectives of the research are explained. Respectively, it is also provided conceptual background, methodology with questionnaire design and data analysis. Sample and data collection are given with empirical findings including before Covid 19 period, after Covid 19 period, and all empirical findings. In the last part of chapter 3, measuring the in-depth interviews and open-ended questions is provided. In the last chapter, limitations of the study, discussions related the study, and suggestions for further research are provided.

CHAPTER ONE
CONCEPTUAL FRAMEWORK OF SUPPLY CHAIN

This chapter contains the theoretical framework of the study and gives information on Supply Chain (SC) concepts and terms as well as the management processes.

1.1. DEFINITION of SUPPLY CHAIN

Supply is the procurement of the right product, at the right form and with the right with the right quantity. When supplied product is manufactured by supplier, the company needs to provide its own raw materials with the same way. By this way, the supply chain is formed that going back to the first raw material. SC is the integration of chain partners; supplier, manufacturer, distributor, retailer, and transporter that they aim to provide the product from the point of origin to the point of consumption and it includes all processes (Tanyaş, 2010). It is a system that provide each product, inventory, and transportation in the market by giving benefit and responsiveness on its processes. Every company that produces product or service belongs to a supply chain. The management of SC depends which SC management applied in long term or short terms periods (Autry et al., 2010; Ganeshan et al., 2000).

Technically, SC is a network that carry out material procurement processes and transform them work in progress goods or finished goods, then deliver those products to the customers via distribution channel. This network performs procurement of materials, transformation of materials to components or end products, at last, it accomplishes the distribution function of end products to the customers (Özkan et al., 2015).

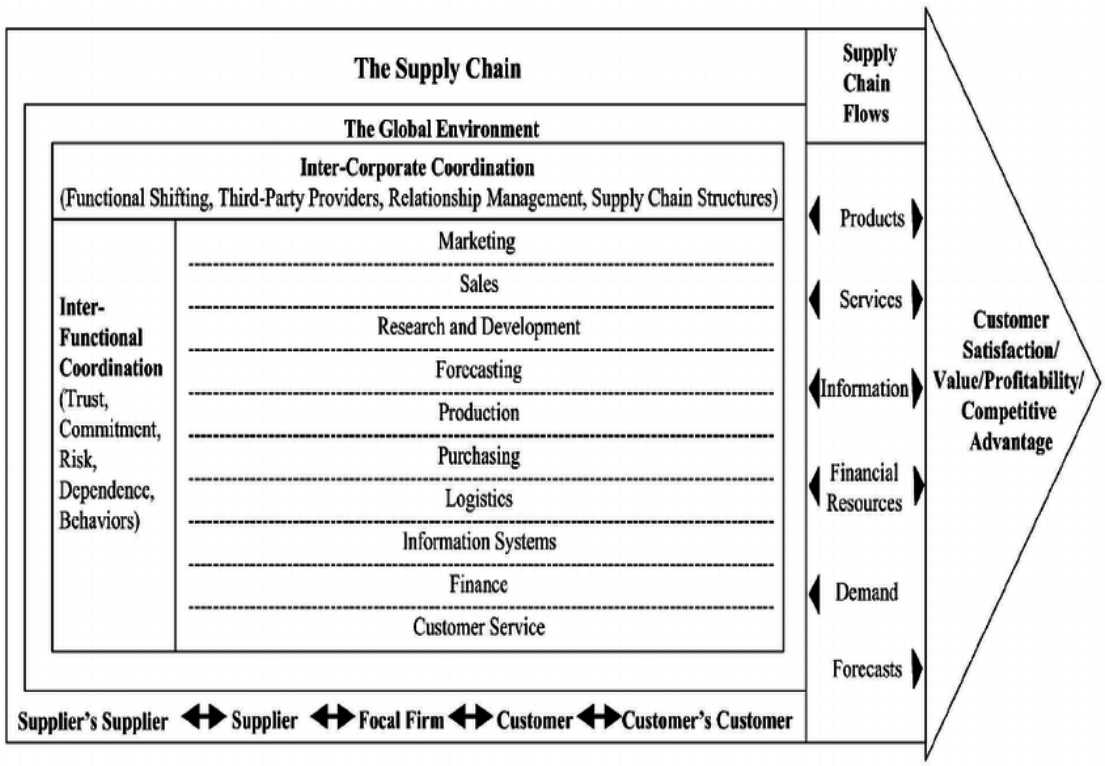
SC encompasses supply and demand management, raw material procurement, production and assembly, inventory management, order management, and product distribution to clients, as well as the information systems that support all of these processes. (Akman and Alkan, 2006).

There are various definitions about SC from academics. SC is the management of processes between suppliers and buyers in terms of having much lower cost and

much higher value added (Christopher, 2005). According to Lambert et al., SC is the alignment of organizations that provide product and services to the market (Lambert et al., 1998). Moreover, Chopra and Meindl define the SC as the chain that meets the buyers' requests directly or indirectly which includes not only producers and suppliers but also transporters, warehouse service providers, retailers, buyers, and other actors (Chopra and Meindl, 2001). According to Ayers, SC is the management of the ongoing process of sending the products and information obtained from the suppliers to the buyers according to the needs and demands of the buyers (Ayers, 2000).

All these definitions related with SC reveal that it is a holistic process that embodies all organizations in the SC process with a coordination and allow these organizations minimizing their cost while maximizing overall efficiency. All SC partners try to reach the same objective rather than setting a goal on their own and heading towards that goal. For this reason, SC members have to organize towards an objective and focus on that objective together (Ketchen and Giunipero, 2004).

Figure 1: A Model of Supply Chain Management



Source: Mentzer et al., 2001: 19

In Figure 1, it is given the steps of production and customer, it is also provided functions and some flows of the SC. Figure 1 provides a roadmap and prompt to professionals to incorporate all common business tasks into supply chain management processes, planning, and structure. The full potential of supply chain management cannot be realized without such cross-functional collaboration. The same may be stated for any supply chain management planning, structure, or procedure that incorporates all supply chain flows.

1.2. DEFINITION of SUPPLY CHAIN MANAGEMENT

The interest towards Supply Chain Management (SCM) has been increasing since the 1990s. SCM can be explained under three headings. These are activities, profits, and components. All of them are divided into sub-headings within themselves. Supply chain management embodies various aspects of an organization from the strategic level to the tactical and operational level as it attaches importance to the process of ensuring an active integration of suppliers, manufacturers, warehouses, and stores (Houlihan, 1985).

Activities include material and information flow through internal and external networking. SCM contains sharing of products, information and financial information in the organizations while responding to customer needs within entire supply chain (Angulo et al., 2004).

In the 1920s, a physical distribution system was needed to solve the problem of delivering large quantities of products to retail centers because of the emergence of large supermarkets and increase in mass production. Physical distribution is the concept that implements together both transportation and storage activities which will ensure the physical movement of the final product from the end of the production line to the consumer and from the source to the production line of the raw materials efficiently and effectively. The first stage of the SCM starts with physical distribution, and it is also asserted that it provides a competitive advantage with in-channel integration of the distribution (Bowersox, 1969). In the 1960s, because of the movements from physical distribution to large, diverse, and small-volume production, the concept of logistics began to be used (Houlihan, 1985).

After the mid-1990s, the effect of the goods and services received from the suppliers on customer satisfaction was realized, and it was aimed to produce quality products and deliver those products to the customers when, where, how they wanted and desired amount with a cost-effective way. As a result of these developments, company managers entered the management of their own companies. They understood that they needed to integrate the management of the network of suppliers, as well as the entire network of companies that deliver products to the end customer and also provide after-sales services (Handfield and Nicholas, 1999).

Later, within the development of information transfer and communication systems between organizations, the supply chain management phase has been started. Thus, in order to increase the long-term performance of the supply chain and all companies in this chain, business functions and plans of these companies are built with systematic and strategic coordination to include all companies in the chain (Tanyaş, 2010).

Increasing customer satisfaction, service quality and competition are among the characteristics of the supply chain. The supply chain increases efficiency and effectiveness as well as reducing the costs and resources. SCM should also have an aim that prioritizes reducing inventory levels and individual costs while increasing profits and improving collaboration (Stadtler, 2008). As it can be understood, SCM has great importance for companies to increase customer satisfaction, service quality, efficiency, and effectiveness, and also reduce both costs and resources.

The objectives of SCM may also include specific purposes that may vary according to the supply chain structure. Each supply chain develops mutual and specific objectives for all chain members, and it implements the activities that related to these purposes in order to achieve its goals (Tan, 2001). These goals are adding value to ensure customer satisfaction, increase the productivity, profitability and market share of all supply chain partners, and minimizing the risks.

1.3. THE COMPONENTS of SUPPLY CHAIN MANAGEMENT

In the contemporary business environment, there four main functions of supply department; conducting market research for the goods to be purchased, estimating the

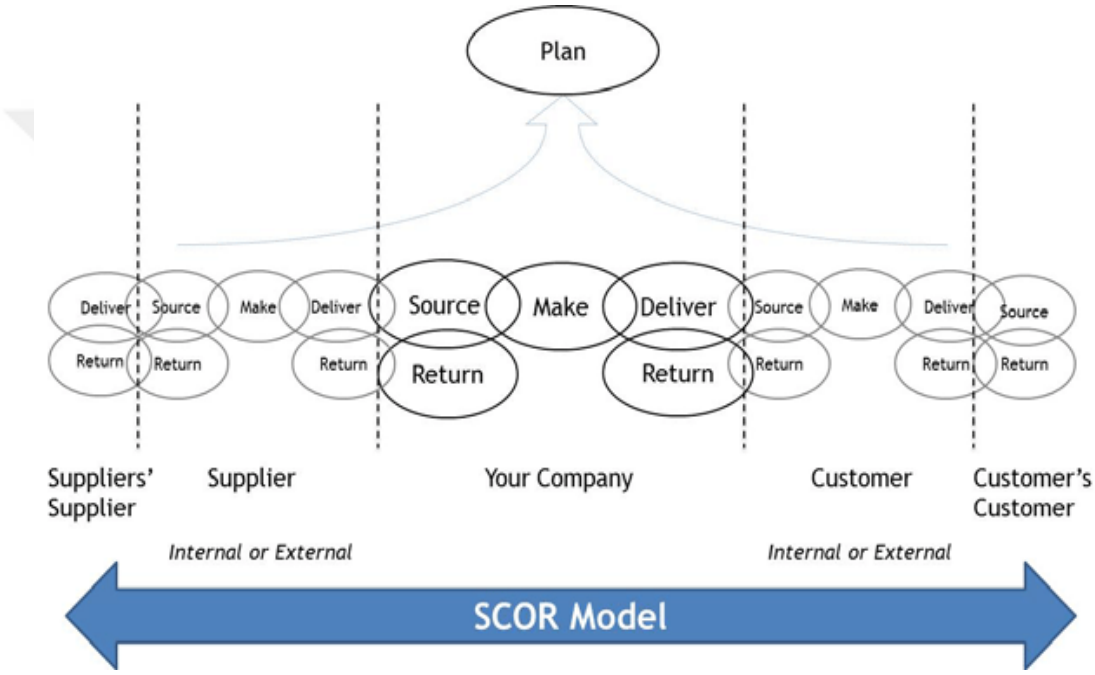
demands of the goods to be purchased, establishing relationships between supply sources and needs, transportation, and storage of purchased goods to the company. SC embodies procurement, product design, production planning, materials management, order movements, inventory management, transportation services, warehousing services, and customer services.

According to Supply Chain Operations Reference (SCOR) model, it is aimed to establish a mutual and model for implementing, developing, and communicating effectively through SC. The model was both developed and established by Supply Chain Council. Basically, the SCOR model consists of components, and all components add value to production processes (Huan et al., 2004).

In the beginning companies need to decide their operation strategy in detail. Therefore, planning takes part on top in companies' agenda. In this phase they need to decide where they are going manufacture the product, offshore or onshore. On the other hand, they need to decide how they are going to produce the product; whether they will use their own resources or use outsource. Thus, companies will start planning strategically in terms of the benefits and challenges that they face. At the best reasonable price, at the right time, in the right quality and quantity procuring or sourcing phase starts. Especially companies need to pay attention the delivery process for supplying raw materials and components. For the next stage, companies need to pay attention their location because suitable or ideal location is crucial for the accessibility of the goods and resources. The operations such as testing, assembling, handling, storing data or packing generates this phase, for those activities some rules are established in order to analyze the performance measurement. Next stage, delivery, it is the part some logistics processes are formed. Ordering, distribution, transportation, warehousing, or some other processes are included in this stage. Moreover, in this stage, it is also performed some business processes in terms of companies' foreign trade activities such as invoicing or documentation to deliver the finished product. In the last stage, return policies of the product should be carried out with easy process. Companies need to put some rules for monitoring their performance, cost or inventory levels for their returned products. Thus, understanding the fundamental points of a supply chain and getting organized leads organizations to take some steps from the beginning of production (Lambert and Cooper, 2000). The Figure 2 below shows how

these components work in successful supply chain management. A schematic representation of the SCOR® model is shown in Figure 2, which also shows how SCs are related to one another. The company's organizational strategy, material flow, and information flow should all be in line with the five integrated processes. From the customer's customer to the supplier's supplier is the range of the processes. (Du Toit and Vlok, 2014).

Figure 2: The SCOR Model adapted from The Supply Chain Council



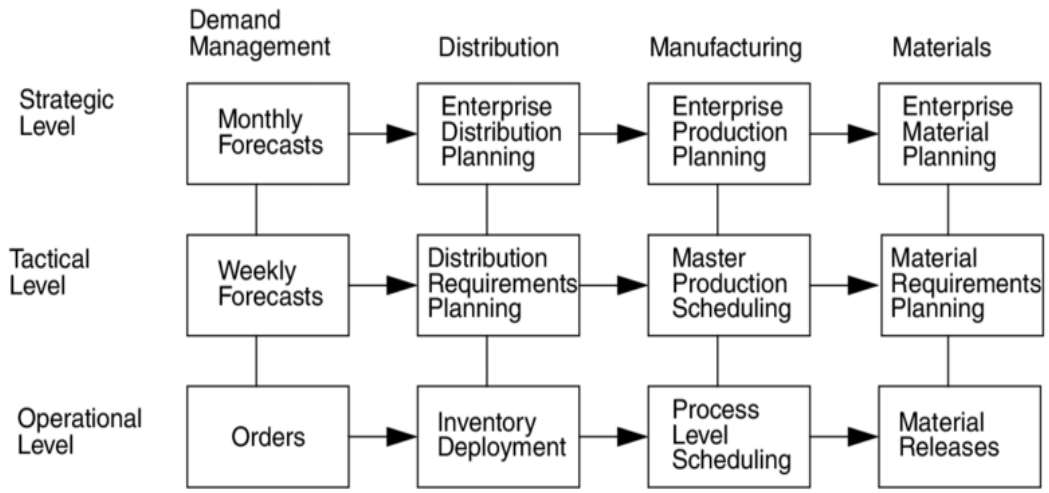
Source: Du Toit and Vlok, 2014: 29.

1.4. SUPPLY CHAIN MANAGEMENT PROCESS

When the main objectives of SCM are expressed, increasing customer satisfaction, reducing the cycle time, minimizing inventory and inventory-related costs, reducing product defects, and lowering the operation costs are considered as the initial activities (Kehoe and Boughton, 2001). Owing to carrying out these activities successfully, organizations should establish mechanisms and levels identified by the Global Supply Chain Forum. These are customer relationship management, customer

service management, demand management, order fulfillment, production planning, procurement, product development and returns management.

Figure 3: The Supply Chain Management Functions



Source: Fox et al., 1993: 2

In Figure 3, SCM processes are segmented as strategic, tactical, and operational level. Monthly and weekly forecasts and orders are analyzed in demand management function for all levels to determine the required amount of inventory. When the distribution section is analyzed, personnel, equipment and vehicles are all determined at the strategic level. At the tactical level, the planning part is carried out for the amounts of products. At the manufacturing section, necessary scheduling is conducted at the tactical and operational level after strategical plans. For the materials part, corporate planning is formed in strategical level, material requirement planning is determined at tactical level and processing is carried out at operational level (Fox et al., 1993).

1.4.1. Customer Relationship Management

Today, the effects of product-based strategies are losing their importance, yet the importance of the services offered to customer is increasing day by day.

Organizations achieve and maintain similar conditions in terms of product quality and product prices. At this point, factors such as offering the product, delivery to the customer and after-sales services build differentiation strategies.

This process is a system that analyze the approaches for improving and maintaining the customer relations. Management chooses the target customers or groups as a part of the organization. They prepare a “product and services agreements” to fulfill the customer needs. Managers work with important target customers in order to improve processes, minimize demand variability and non-value-added activities. The department that manages this process also prepares performance reports for analyzing the profitability and performances. Increasing competitive pressure in the markets and product similarities have made product and service differentiation gradually. Moreover, decrease in profit rates directs the organizations to reconstruct their marketing operations (Özilhan, 2010). Reorganizing the customer relations in order to carry on reaching and retaining the customers, following micro segmentation levels, differentiating the customers on their profit rates and setting up information technologies to monitor the customers become more significant. These recent developments are tried to be met with the feature called "Customer Relationship Management (CRM)," which can be considered a revolution in marketing (Xu, 2002).

Ensuring the customer satisfaction in SCM is one of the most significant approaches for having competitive edge. the management of customer service is another factor affecting customer satisfaction.

1.4.2. Customer Service Management

Most of the time, company and the customer are face-to-face in the supply chain process. Customers are always informed about the matters such as availability of the goods, shipping date, or order status. Information on organization’s manufacturing and logistics processes can be accurately provided thanks to the interfaces formed with contractors. Customer service management are responsible with implementation of the product and service agreement made with the customers (Korpela et al., 2001).

While customer service management provide information on the points such as delivery days of orders or order status, real-time data processing can be provided by the coordinated work between the functions of the organizations during the production and logistics activities. Strategically the aim of the Customer Service Management is to establish an infrastructure and ensure the coordination to have connection with customers (Tan et al., 2002).

The technological solutions are also provided on customer service management. For instance, gathering all the demanded different service capabilities such as e-mail, telephone, internet and intranet under a management, and the possibility of planning and controlling all these service network gives organizations boost on their operations. Service demands gathered under a single management monitor all the process, manager directs the customer requests to the technical staff and by this way, they can respond reliably, swiftly, and correctly. It is also possible for them to monitor the status and sign off periods of incoming service requests, by this means they can keep under control the service operations and improve service quality for the organizations they serve.

1.4.3. Demand Management

Demand management is the ability of organizations to understand customer demand and balance that demand with supply chain capacity. Organizations focus on efficiency criteria as a basis while manufacturing. Efficiency, with its simplest definition, is to produce in a way that provides the most benefit with the lowest cost. In this context, organizations don't want to produce more than they can sell, nor do they want to produce less than they can sell. Organizations that produce more than they can sell have to both bear the cost of inventory and sell the remaining products at very low prices. This means huge loss for businesses. Organizations that produce less than they can sell, on the other hand, miss the chance to make more profit, and their reputation also will be damaged. Therefore, the amount of production is a very important balance issue and the way to achieve this balance is to organize demand management (Lambert and Cooper, 2000).

In this process, it is tried to compensate the needs of the customers and the supply possibilities of the organization. Demand forecasting and production with this forecast, purchasing and distribution are tried to be coordinated. This process mostly focusses on developing alternative plans and manage these plans when the operations stop or faced with unexpected incidents (Krajewski et al., 2010). Demand forecasting is important for organizations because the demand for a product or service affects many important decisions that the business will take such as the number of employees, the number of raw materials to be procured, the lead times, the number and quality of the machines to be purchased.

Demand management is the ability to understand the needs of the customers in advance and it is the ability to adjust supply chain capacity in accordance with these needs. It is tried to balance the customer needs and the production possibilities of the organization with demand management activities. While analyzing the demand, various statistical methods are used (Rexhausen et al., 2012).

The first point for planning future production activities is the quantities that have to be produced or are desired. If the demand for the product targeted to be produced cannot be estimated, the planning process can't be generated. Estimated demands are the main data in the determination of raw material, components, semi-finished products, labor force, machinery, and investment requirements. The errors made in demand forecasts will adversely affect the entire supply chain management process and reduce performance (Sheu, 2010). A well-executed demand management is effective for ensuring customer satisfaction.

1.4.4. Order Fulfillment

Order fulfillment has a crucial role in SCM as it directly responds customer needs for fulfilling orders. A successful order fulfillment process necessitates the integration of a company's manufacturing, logistics, and marketing strategies. To meet consumer expectations and decrease the total cost of delivery to the customer, organizations must form relationships with important members of the supply chain. If these stages are followed, the supply chain will have an efficient order fulfillment process. (Dinçer, 2009).

Marketing logistics begins with the order process of customer. Today, almost all organizations try to shorten the transactions such as acceptance of order, deliver the order and payment of the order processes. Mentioned processes have some steps. These steps are ttransmission of the order by salespeople, entry of order and checking the customer, programming of inventory and production, transferring the order and invoice, and making the payment (Kotler et al., 1999).

Electronic Data Interchange (EDI) is an electronic exchange process all businesses in the supply chain conduct with commercial document flow (waybill, invoice, order, etc.) depending on international norms. Organizations that implement supply chain applications, transporters, customers utilize the EDI applications in order to make data interchange electronically by using information systems like barcode printers and readers connected to all these systems. At the first stage of EDI systems, the organization prepares the purchase order, and transmits the data related to the electronic media to the supplier. The information has reached the supplier in a structured format is recorded in the system as an order entry via a software. The order processing system starts the process of preparing the incoming request after the necessary arrangements are made as in the orders written on the paper (Premkumar et al., 1994).

In the other process, it is dealt with the documentation work. After the acceptance of the order is approved, the loading invoice, selection instructions, packing slips are prepared and the invoice is prepared. During the order selection part, goods are selected and packaged and made ready for loading. After the loading approval is prepared, feedback is provided to the customer service management. In the last process, after the receipt and posting of the fee, the post-distribution activities which include the recording of the debts and performance measurement are dealt with. Then the feedback is provided to customer relationship management, supplier relationship management and income management (Croxton vd., 2001).

1.4.5. Production Planning

One of the main points of SCM is production planning and control systems with a focus on internal integration from external integration. This section deals with

providing the necessary manufacturing flexibility for the products that are manufactured and served to the target market in the best possible way. Production planning also includes the production operations and product flow related to acquiring the product. Production planning part has significant variables that directly affect performance criteria in supply chain management. The limits of today's production planning and control transcends enterprise resource planning (ERP) and related systems that optimizes performance within the firm by coordinating the flow of materials and information. Supply chain management has the purpose of managing these flows within the company with the awareness that has complete control will lead to major improvement (Samaranayake and Toncich, 2007).

Improvements have been made in business activities thanks to material requirements planning/ enterprise resource planning (MRP/ERP) and other business or business unit-oriented systems. However, today the main opportunities take part in more global advancements such as production planning and control systems that provide synergies between supplier-customer in business units. In addition, modernization of the company and supplier, reduction of supply chain stocks, reduction of chain response time, lowering the holding cost, shortening the time for penetrating the market, responding faster way for market demands, syncing schedule between companies, and eliminating inter-firm transfers are the other examples of production planning stage (Stevenson et al., 2005).

If the organization can quickly change the amount and type of the goods, inventory costs due to fixed production can be reduced. However, flexible manufacturing may require additional equipment, place, and personnel to meet high demand. Machinery and equipment which are idle position or incompletely used during the periods of low demand have to bear the labor cost. Alternatively, the points related with employment such as temporary or part-time employees, hiring new employees, or firing employees can be also arranged. Production capacity in the short run, outsourcing, and contract works can be increased (Doğruer, 2005).

1.4.6. Supplier Relations Management

The general relationship between businesses and suppliers in the past years; it was only in a structure that focused on the best for the moment, especially the most affordable price, reserved, not based on trust, low business affiliation, inability to move mutually, short-term, one-time business, and discontinuous. However, under today's consumption economic conditions with the shortening of the product life cycle, organizations need more raw materials, semi-finished goods, materials and services day by day. Therefore, in this process, to maintain competitiveness, reduce costs and in order to increase product quality, organizations had to build better relationships with their suppliers. By this way, organizations stay connected to their suppliers.

It is a process that defines how the firm will develop relationships with its suppliers. Supplier relationships and management are crucial for the side agreement that depends on each firm's external skills of the design and manufacturing components. Thus, managers need to decide whether to maintain mutual collaboration and long-term relationships with their suppliers, or not, on the points to get the best quality products at a given price, trust in short time connections, and from product development to manufacturing (Cusumano and Takeishi, 1991).

It is an important and necessary element to maintain the supplier relations at the expected level. Supplier relations management is also covering the interactive relationships formed in the environment determined by external factors such as market structure, internationalization, social structure, position in the chain. It is also anticipated that relations with supplier is mostly defined with the technological aspects with objectives and experiences. Scale of an organization gives a flexible ability to a firm on how to meet the customer expectation. Suppliers most of the time focus on the price if the partners have equal conditions on negotiation points. In addition to all these, if the suppliers have capabilities on organizational structure and capacity for providing their goods in time, the relations will be stronger and permanent, and their business performances also will be improved (Sanders, 2005; Bensaou, 1997).

1.4.7. Product Development

In today's competitive conditions, designing new products are significant for continuity of organizations. Designing the right product is a strategic decision for businesses and provides competitive advantage. In this point, by referring right product, it meets the needs of customers and meets their expectations. Product design is a process that is affected by many economic, social, demographic, political, competitive, and technological factors. One of the most important elements in here is technology, since many product design needs arise from and become possible thanks to technological developments (Stevenson, 2015).

While developing a new product, it should be considered whether the product is functional or innovative. Functional products require an efficient process, yet innovative products require a highly responsive process. Providing supply chain coordination according to the new product is very important in terms of efficiency. When making decisions based on new ideas and technologies, managers should also evaluate their supply chain capabilities. It is necessary to design a new supply chain in accordance with the nature of the new product. Otherwise, businesses may suffer great losses (Petersen et al., 2005).

Developing new products is an important element of the supply chain because the material and information flow that needs to be procured for this product is the main subject of the supply chain. The goal is to get into the market on time. At this point, it is important to include customers and suppliers in the product development process in order to reduce the process of introducing new products to the market. In addition, with the rapid exchange of information, customer needs will be determined instantly, and the requested goods will be able to enter the market quickly (Feng and Wang, 2013).

1.4.8. Returns Management

It covers all activities related to returns in operations. Effective returns management is a critical part of supply chain management. Effective returns management can create an opportunity to achieve sustainable competitive advantage.

Moreover, this process can help organizations find ways to increase their productivity and develop their projects (Mollenkopf et al., 2011).

An active returns management is the most important part of the supply chain because return management, which is included in the concept of reverse logistics in supply chain management, is a very important link in the process. Returns management failure will quickly affect the performance of the supply chain network negatively. Within this context, there will be failure on customer satisfaction, accordingly it will be reflected in sales and marketing activities (Lambert et al., 2005).

In this point, it will be better to explain from a case. If a product that has been shipped is found to be faulty or incorrect due to a possible reason, the transporter is contacted, and the product is prevented from being delivered to the customer. If it cannot be happened, the customer is contacted to try not to unload the goods from the vehicle. If the item has reached the buyer, the relevant return should be immediately received, and the correct product should be sent to its place (Çancı and Erdal, 2003).

1.5. THE ADVANTAGES of SUPPLY CHAIN MANAGEMENT to BUSINESS

We can examine the importance of supply chain management on social roles and businesses. If it is mentioned about social roles briefly, SCM's knowledge and skills can be executed in the conditions like disaster relief activities, in the health sectors, and in similar emergency cases. It provides significant advantages on meeting the needs of people by using it in the elimination of problems, prevention, and reduction of disruptions (Alghababsheh and Gallear, 2021).

On the other hand, for organizations, a well-established SCM function plays a significant role in the performances of businesses by providing financial empowerment, operational optimization, and better service to customers. According to various academics, SCM is considered as an implementation of management philosophy. SCM will be successful if the organizations follow these steps; integrated behavior, joint information sharing, joint sharing of risks and rewards, collaboration, integration of processes, establishing and maintaining long-term relationships (Bowersox and Closs,1996).

Today, businesses give their place to supply chains. The success of the business has begun to depend on the success of the supply chain in which it is part of. With the increase in competition on national and international markets, organizations have various options to meet the demands of their customers. Therefore, convenience level of the products and providing them with minimum cost achieved organizations great opportunity. With the changing purchasing habits of consumers, there is a challenge for organizations to produce new products or improve their own products. Shifts on demand have increased the risk of businesses for holding inaccurate inventory. In addition, by maximizing the performance of a department or function of a business, it has been understood that it is not possible to ensure that the entire organization achieves optimal performance. From now on, organizations are searching for suppliers that provide lower cost and quality materials rather than using their own supply resources. Thus, they become more specialized in their own field of expertise and with the holistic management of the supply network, they gain great advantages by optimizing the entire business performance (Lummus and Vokurka, 1999).

The right product, the right quantity, the right place, the right time, flexibility, minimum total cost, the shortest cycle time, and the minimum total stock level are among the critical success criteria of SCM. In order to meet these criteria, SCM focuses on the systematic and coordinated processing of products and information flow through the SC for mutual purposes. The main purpose of SCM is to achieve higher profit margins on the final products that the customer demands. Businesses can increase customer satisfaction with this way, and they can get competitive advantages and become more permanent in the markets.

1.6. THE FACTORS AFFECTING SUPPLY CHAIN MANAGEMENT

It is considered that in the long run SCM provide organizations an effective solution to arrange their deliveries on time, improve their financial situations, provide a perfect customers satisfaction, build a strong partnership dynamic and so on. However, even SCM has that much huge impacts on organizational performance, it is also important to understand and work on some factors and challenges that can change the organization’s performance other than usual aspects (George and Pillai, 2019).

Organizations need to pay attention their SC structures as the material and information flow increase the complexity level of the SC. Therefore, the bullwhip effect which can be described as to fluctuating on the demands from the point of origin to point of consumption. The effect penetrates from raw material supplier to retailer. Therefore, supply and demand metrics change in a negative way. The complexity of the SC structure can increase the bullwhip effect in the long run (Bottani and Montanari, 2010).

Economically there should be a balance for the costs for organizations' inventory levels. On their basic decision, companies need to act for each material in their stock. These actions are related with order timing for each stock and the size or amount of order for the stock. Therefore, it can be assured that decisions on inventory management can be taken regarding with when and how much order need to be done (Boute and Lambrecht, 2009).

One of the biggest factors in SC performance is to share the information among the SC partners. Information sharing can provide both connection and coordination for the activities in SC. It is not only significant for routine activities of SC, but also it is important for international basis. It enables to understand the customers tastes on the products and services that the organization produce. Therefore, with a successful technological background, organizations can generate new information continuously for their partners in time and with high quality, and it improves the SC performance permanently (Hatala and George Lutta, 2009).

Customer demand is the other one that can be considered as environmental factor for SC performance. In most sectors, it can be said that demand is very difficult task to forecast for managers. The reasons are; there is fluctuating on demands from customer point of view, when the SC partner order to the other upper stage SC partner, there will be also fluctuation and this will lead bullwhip effect. The instability on customer demand will drag organizations to have high inventory capacity levels and inventory costs. There are also various demand patterns such as seasonal, constant, or other trends, so these demand patterns will affect the total cost of SC and the levels of services as well (Boute et al., 2007).

Organizations need to follow decent forecasting methods to prevent the disorder of SC performance. It is almost impossible for organizations to predict the

accurate demand tendencies for the future. Because of this uncertainty, there will be issues on order quantity and shifts on orders. Consequently, SC performance will be affected by the accuracy of the forecast capability. A misdirected forecast method will cause the issues on the capacity of the organizations (Shang et al., 2004).

There are some other parameters that can be considered to affect the SC performance, lead time is one of them. If there is time gap between receiving an order and delivery of the order, it can be defined as lead time. Long lead time causes issues in the SC inventory levels such as shortage of a product or collapse on inventory for the long run. On the other hand, short lead time increase the efficiency of activities in the SC processes (Berling and Farvid, 2014).

There are some points for organizations to reorder a product or not in accordance with the time they have chance to evaluate their inventory level status which is referred as review period. The demand trend of a product reveals the optimum selection point for the review period. Moreover, both longer review periods and shorter review periods can cause problems such as decreasing total expected cost or high carrying issues are expected. Therefore, the length of the review period is crucial for SC performance (Movahed and Zhang, 2015).

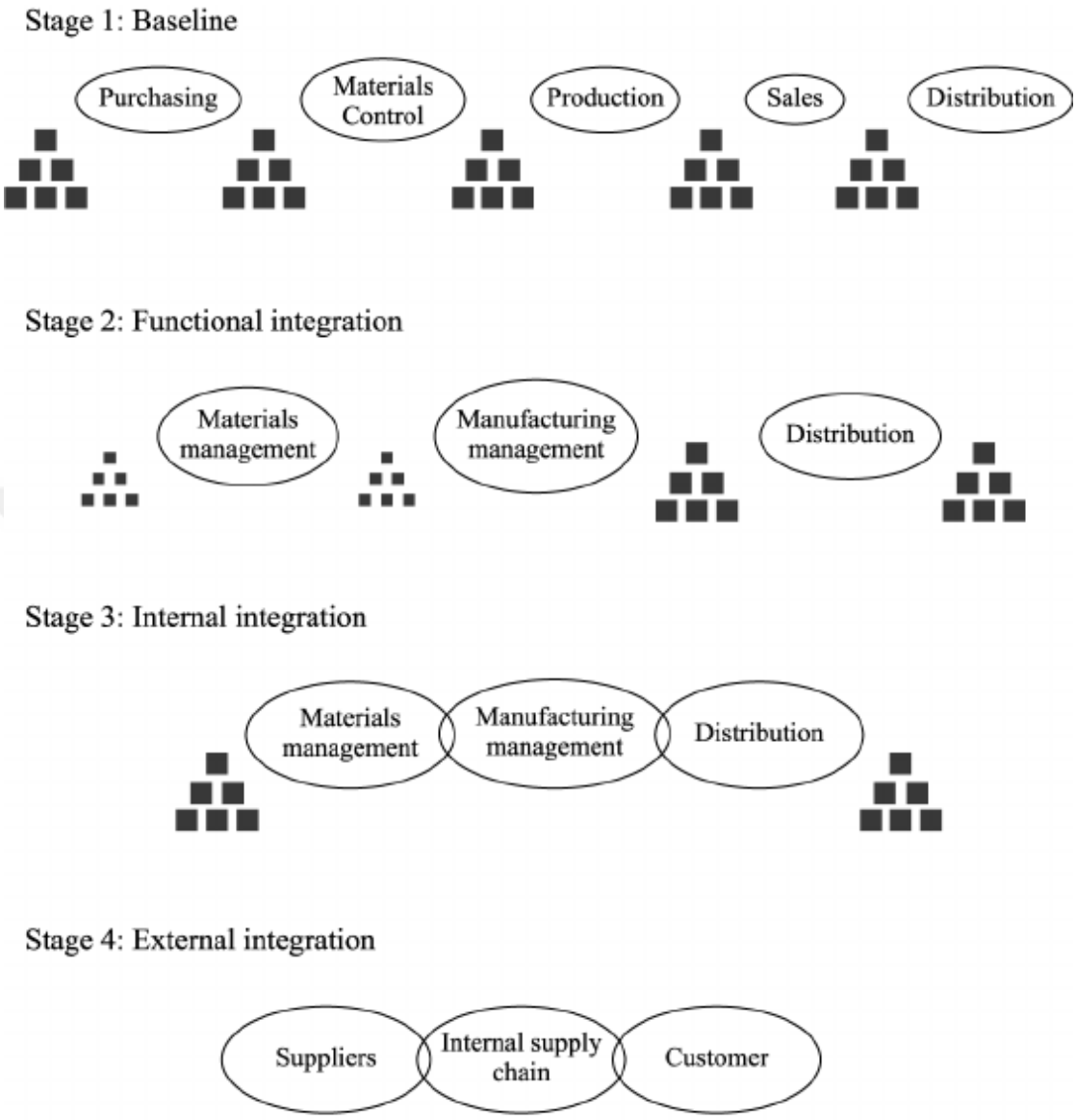
1.7. THE SUPPLY CHAIN MANAGEMENT INTEGRATION

It is a difficult process for organizations to implement perfectly integrated SC. One of the problems that can be seen in many cases, there are issues for employees who needs information immediately, yet because of the inadequate information systems, they can't reach that information. The other one is, even there is information systems desired level, because of there is lack of trust among SC partners, they don't share that information regarding with concerned about leaking information to their competitors (Handfield and Nichols, 1999.

An integrated SC adds value for SC partners and all shareholders beyond reducing the costs. Integration is based on information sharing. After that, it comes the co-ordination and interconnecting the organizational fields, which refers to the sharing of risk, costs, and benefits. With the SC integration, profitability, market share, competitiveness, and value of the firm increase. The success of organizations depends

on the correct use of information which leads the compatible management of activities in the chain (Lee and Whang, 2000). Sharing information and coordinating logistics activities are important in terms of trust between partners. With the integration shared information has become important again for all stakeholders (customers, retailers, wholesalers, distributors, and suppliers). The absolute balance between supply and demand can be achieved with a suitable integration for customer satisfaction and firm performance increase. In Figure 4, four different stages take part for reaching integrated SC. In the figure, it is also seen that there are several organizations, and functions of all areas covers organizations for the development of the stages of the integrated SC (Christopher, 1994).

Figure 4: Stages for an Integrated Supply Chain



Source: Christopher, 1994: 7

1.7.1. The Supply Chain Integration and Information Technologies Infrastructure

The system which connects the organization to its suppliers, distributors or customers is called the information system. Information technology infrastructure allows organizations to connect SCM which is one of the complicated resource types.

Information technology infrastructure is generally divided into two main groups: These are the technical and human infrastructure of information technologies. Managerial IT capabilities often depend on the developed relationship between people over the years (Patterson et al., 2004).

Integration increases in direct proportion to productivity and production. The effective integration of suppliers into the SC is a very significant factor for achieving competitive advantage. The higher the integration between suppliers and customers means the greater possible profitability. SC integration eliminates inefficiencies and instabilities, so it increases its performance by directing the processes in the right way, giving customers what they want, avoiding excessive inventory levels and by regulating demand actively (Agan, 2011).

1.7.2. Effective Scopes of the Supply Chain Integration

The most important way to build a successful and efficient SC is to bring together various SC members and ensure that they can work together. SC integration can be explained by the level of coordination. IT is very significant for this task to perform properly, and it is also necessary to work in four areas to achieve this task: Sharing information among SC members in order to improve the performance of the SC, collaborative planning (shared information): coordination on workflow (supply chain partners can work together): and adaptation of advanced technologies to the system (affairs of supply chain members in order to improve and redesign SC performance). Collaborative planning, forecasting and replenishment is the process that two or more organizations synchronize their personal demands with customer demands to produce a product for customer satisfaction. In this process, each SC member need to share supporting information such as forecasts, comments, sales trends, information about sales, product information in inventory (Whitley and Ulmer, 2013).

Traditionally, planning, purchasing, producing, marketing and distribution are performed independently of each other in the SC. Each department deals with the part under its responsibility. However, generally all of these make the operations more complicated. For example, marketing's efforts to maximize customer service and sales

may conflict with production and distribution goals. Most manufacturing operations aim to achieve the lowest cost of inventory levels and distribution capability. All these complexities make it important to put the SC under a network. Coordinating the communication between the functions of organizations in this chain is the most important element of a balanced SC network (Buurman, 2002).

1.7.3. Relationship between the Supply Chain Integration and Information Technologies

There are many technologies for analyzing and sharing information in the SC. Among these technologies, some of them are used widely in all process in SC; Electronic Data Interchange (EDI): Internet, Enterprise Resource Planning (ERP): Radio Frequency Identification (RFID) and Supply Chain Management/Planning (SCM/SCP) technologies. Therefore, managers must decide which technologies to use and how to integrate these technologies into their own businesses and their partners' businesses. As the capabilities of these technologies increase, these decisions become more important day by day (Gupta, 2000). It is also seen in the studies that there is a parametric relationship between information technologies and integration and this relationship affects firm performance.

The top-down and bottom-up information flow in the supply chain network is very important. Ensuring this flow of information flawlessly depends on the basic mechanisms (Frohlich and Westbrook, 2002). These are information technology capabilities, a good coordination platform, participation, problem solving activities and integration. Moreover, there is relationship between the organizations with long-term suppliers and logistics integration of information technology capacities and information sharing. It is also explained that long-term supplier relationships have been expressed as direct and indirect effects on performance (Prajogo and Olhager, 2012).

IT infrastructure has two important sub-components. Technical information technology infrastructure and human information technology infrastructure. Managerial information technology capabilities consist of implicit knowledge and knowledge that has been developed within the organization for years. For this reason,

the development processes of these skills are complex and depend on the information technology applications developed by the managers, suppliers, and customers. It is thought that performance increase can be achieved when these two infrastructures integrate with each other and integrate into the SC (Chatfield and Bjørn-Andersen, 1997).

Although technical structure, which is one of the sub-concepts of information technologies, affects the integration and does not evaluate the human dimension, it can now be stated that human and technical infrastructure together affect the supply chain integration and there is a relationship between them. Therefore, this reveals the other dimension of IT and SC integration (Bush, 2002).

1.8. COVID-19 IMPLICATIONS ON SUPPLY CHAIN MANAGEMENT

After the Covid-19 pandemic outbreak appeared in Wuhan, China, it didn't take long the spread of the disease to whole world. Globally, pandemic outbreak caused a huge crisis in the world, at the end, many people either infected from the disease or died. In the beginning of this period as there was no cure or vaccine for the disease, many people infected or uninfected stayed at home during the quarantine period. For this reason, socially and economically, people were affected for a while until some precautions were taken.

Global economies were highly affected during Covid-19 outbreak, because of it, a huge decline in international trade was experienced. The consequences of this crisis were sensed for a while afterwards (Akçacı and Çınaroğlu, 2020). There were manufacturing issues all over the world, and organizations wasn't providing the material or components from their suppliers on time, so there were problems on supply chain structures of organizations. It was almost impossible for organizations to meet the demand at the right time even if there were located close geographic positions with their partners or suppliers. In addition, unemployment problem has also arisen because of the Covid-19 protocols, quarantine, and restrictions procedures. On the other hand, service sector was also suffered from the crisis hugely, as the total demand towards it dropped (Carlsson-Szlezak et al. 2020).

During the Covid-19 period, because of the inventory stockouts and market dominance of suppliers, both logistics activities and SC processes were highly suffered. Socially, in lockdown period, people were get used to work at their home. In this context, people benefitted from the technology and organizations provided them e-commerce backgrounds, by this way, some approaches were highly preferred such as contact-free delivery, fast delivery services of retailers, location tracking and tracing of the goods. These activities provided an opportunity for organizations to improve their value chain operations. The concepts of third-party logistics (3PL) and fourth party logistics (4PL) provide an impact especially to e-commerce operations. Organizations took advantage of these developments and improved their outsource contacts. Consequently, organizations focused on improving their transportation management (Choi, 2020).

Particularly, in the international arena, because of the pandemic there were huge truck lines on border checkpoints as many countries put restrictions on these points. Restrictions not only affected the goods transportation, but it also affected the passenger transportation like all other modes of transport. In foreign trade, as there were delays for the goods on border checkpoints, depending on these delays, the rate of the freight became higher. Especially, maritime transportation between Europe and Asia trade routes were negatively affected for a while (Fernandes, 2020). The increase of freight rates was related to delayed vessels from ports of China as it is center point of pandemic. Therefore, the integrity point of exportation in the world dropped because of these latencies (Loske, 2020). As it is seen in other transportation modes, there was also decline on using road transportation. On the other hand, when it is compared with other modes of transport, there was a positive tendency towards railroad transportation. The reason behind it is when the physical contact is considered it is very important factor for Covid-19 virus to spread, so little physical contact means less risky conditions for railroad transportation (Citroën, 2020).

Airline transportation was also adversely affected because a drop of number of passengers worldwide and increasing rates of freight shipments. Many passenger flights were postponed during the Covid-19 epidemic (Suau-Sanchez et al., 2020). However, for this transportation sector, some precautions were taken to transform passenger aircrafts to airline cargo and conducting some regulations on some routes.

As there was drop on passenger numbers many airlines company decided to use their aircrafts for cargo transportation regarding with the high demand towards airline cargo transportation for fast deliveries. In addition, both cargo flight operations and its transactions such as warehousing, customs procedures were performed insubstantially because of Covid-19 (Li, 2020).

CHAPTER TWO
INFORMATION TECHNOLOGIES AND THE EFFECTS ON SUPPLY CHAIN MANAGEMENT

Recently, with the development of information and communication technologies in SC structure and management, there have been some differences in most of the sectors. The customer-seller relations in the system are now more organized. The development of the relationship between the organization and the customer with the internet has increased the communication facilities and interactivity. Virtual work communities are emerging thanks to the internet and network connections (Gunesakaran and Ngai, 2003). Information has great importance for increasing the efficiency and effectiveness of performance in the SC and helps managers to make the right decisions at the right time. Information technologies consist of tools, equipment, and applications in terms of increasing the awareness for information. The use of information technology facilitates the analysis, organization, and coordination in SC. In recent years, organizations have been using information technologies in order to get competitive advantage and achieve their business objectives. As the field of application of the technologies they use expands, it becomes more important for organizations to make decisions (Özdemir and Doğan, 2010).

Therefore, SCM need to focus on long term relationships regarding with considering the profitability on collaboration and information sharing. Thus, it points out that the use of information technologies in SCM is highly significant. The instruments and facilities they use among SC members should be increased, since this reduces uncertainty while increasing supplier product delivery performance. Consequently, it will help organizations to develop new strategies and improve their SC agility (White et al., 2005).

2.1. THE CONCEPT OF INFORMATION AND INFORMATION TECHNOLOGIES

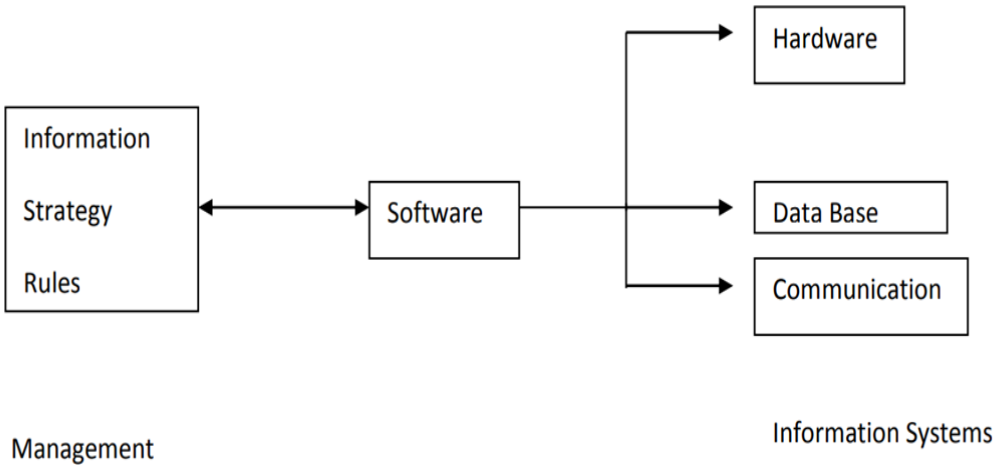
In this section, the concepts and approaches related to information and information technologies will be provided. Information technologies can be defined as technologies that can provide data or data collection, by this way, data can be processed, stored, transferred if necessary, or accessed from anywhere else (Oktay, 2006).

Information technologies (hardware, software, and similar forms) embody half of the organization cost for many large enterprises. Organizations make the investments information technologies in order to ensure the continuity of their assets, to store and analyze the data within the framework of security rather than to provide competitive advantage. Information technologies show many developments in terms of intranet - extranet - internet, hardware, and software systems almost daily basis (Aksoy, 2009).

Information systems and information technologies are closely related concepts. However, both concepts are based on information. It can be stated that information systems focus on the creation of information, and information technologies focus on the use of information and providing it. Thus, the ability to process information and the ability to benefit from information increase the efficiency and performance of the organizations, and it can be also stated that the role of information systems in the organization has evolved and changed over time with the advance systems in information technologies (Masino, 1999).

In Figure 5, the relationship between information systems and management is provided. It can be seen that IT is highly important for the performance oforganizations because functions of organizations and dynamics of organizations such as its strategy and rules, and other components of the organization need to work closely for the organization’s performance (Demircan and Moltay, 1997).

Figure 5: The Relationship Between Information Systems and Management



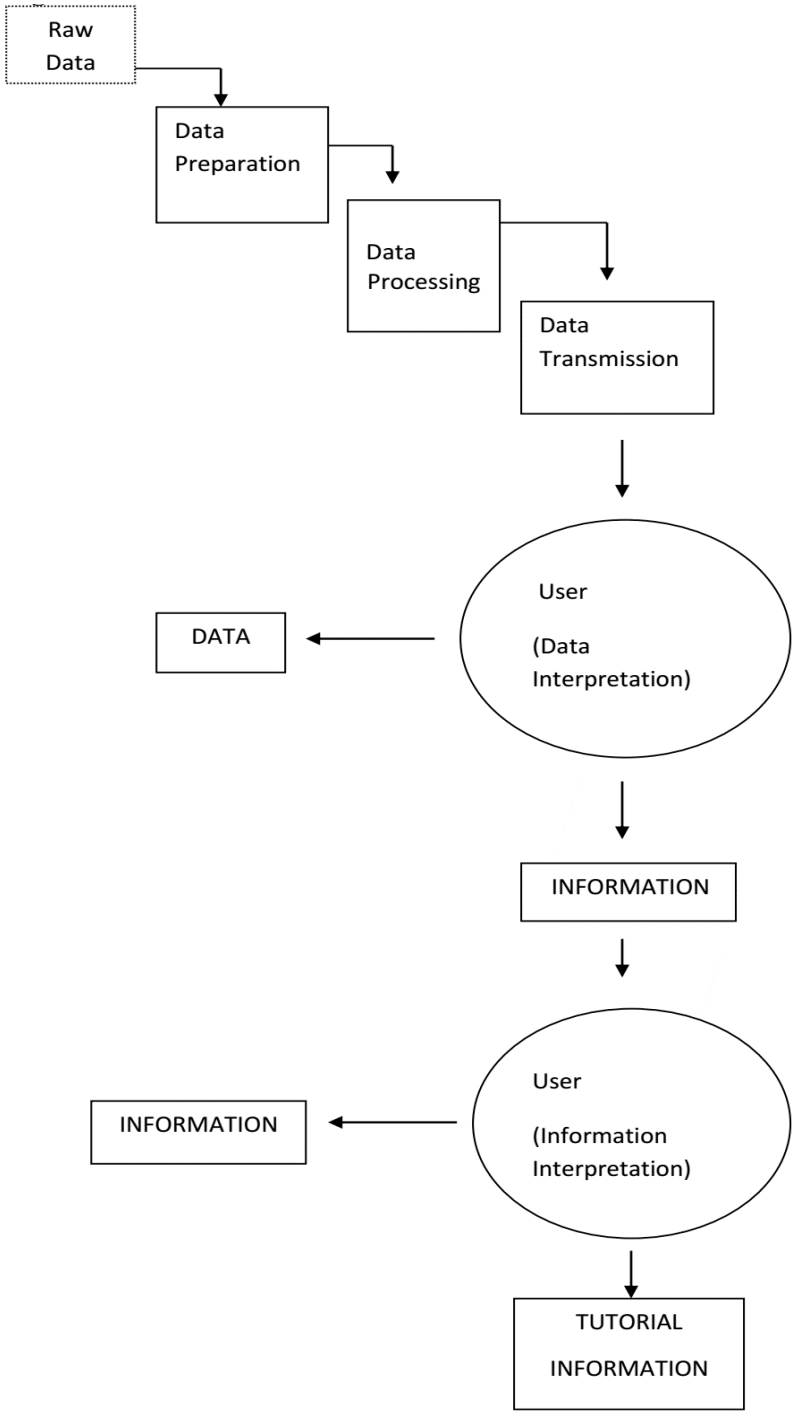
Source: Demircan and Moltay, 1997: 17.

Along with the increasing importance of information, developing information technologies increase the usability of information. For this reason, it is useful to define the concept of information, which is the basis on information technologies.

2.1.1. The Definition of Information

Information is basically defined as the ability to put information into an action that provides a flexible integration for the co-assessment of organized and coherent experiences, values, relevant information, and expert opinions (Liebowitz and Megbolugbe, 2003). When information is acquired, it is revealed and processed in the minds of individuals. It can be discovered not only in documents, but also in all routine works (Davenport and Prusak, 2001). Traditionally storing information was made through books, now it has started to be stored with electronic media. Information is the inference of environmental stimuli and phenomena, and all has no concern about message transmission. However, these implications can be informative if interpreted as a whole. Information is the part of the communication process.

Figure 6: Transformation of Information from Data



Source: Öğüt, 2001: 25.

In Figure 6, basically the transformation of information from data is shown and it can be understood that the meanings attributed by people play an important role in the interpretation of information rather than words or inputs, meanings, timing, and

social factors. It is important that information can be seen as a source of commodity. The receiver interprets the message as intended by the user. Sometimes information may be distorted or altered in addition to messages sent as it is expected to be interpreted (Öğüt, 2001).

2.1.2. The Age of Information and Increasing Importance of Information

Depending on the developments in information and communication technologies, production, consumption, distribution relations and the economic system, which are described as the triple pillar of the economy in the information economy, are all restructured on the basis of knowledge and information has become the main factor of competition in the industrial economy (Bensghir, 1996).

Recently, the differences have been experienced in the economic, social, and technological areas in the world economy are explained by the concept of knowledge economy. These complex processes, which are closely related to each other, have revealed the necessity for societies to think big and live big. As a result of the developments in communication and information technologies, the significant and permanent effects experienced in the economy require the redefinition of many micro and macroeconomic concepts (Kevük, 2006).

In the socio-economic development process, societies have experienced and are going through transition processes from primitive society to agricultural society, from agricultural society to industrial society, from industrial society to information society. The first of the stage which is important in human history, is the transition from primitive life to agricultural society, which connects people to the land and settled order. The second stage is s the transition from an agricultural society to an industrial society where mass production, consumption and education are important. The third stage is the information society process in which welfare, information and qualified human resources are important (Parlar, 2012).

Information is the most effective factor that changes, develops, and transforms organizations from top to bottom. In this context, managing the flow of information, collecting, and using information are issues that modern companies mostly deal with. Utilization of information is the feature that reveals the difference of organizations.

Accessing, managing, and using information determines organizations' success (Özdemirci and Aydın, 2007).

From the points of views of companies and countries, the importance of information has become increasingly important in recent years. Economic activities have been taken on a global structure due to the importance and development of information technologies. In this situation, information provides companies a competitive advantage and by this way companies have spread their activities through information technologies and used information and information technologies as a strategic power in their competitive efforts. In fact, different examples of the information economy have been appeared in all times of humanity (Peoples and Bailey, 2014).

Information economy shows that the transformation of investment in information is higher than capital investments. The value of the information people has in the market is becoming more and more important. In addition, the most important difference that distinguishes the information economy from other economic structures and the industrial economy is that information has a primary priority among economic factors. This means that information is the basis of the information economy (Saygili, 2003).

2.1.3. Information Technologies

In the organizations IT provide solid backgrounds in control and coordination of organizations. Organizational goals and IT can be adjusted with each other with a simple approach; IT enables organizations to manage endless information resources. Therefore, IT can be facilitated not only in control and coordination processes of organizations, but also decision-making points. When it is compared with traditional coordination approaches, IT makes organizations' strategies more effective, useful, and flexible. In this part, the definition of IT, IT Tools and IT systems will be explained.

2.1.3.1. The Definition of Information Technologies

In organizations, information is used in decision-making stages for planning and controlling the effectiveness of the corporation. Information is much more important than traditional production factors consisting of raw materials, capital, and labor, so it has been considered as a very important resource. In this respect, business managers have started to move towards modern techniques that allow the acceleration of business activities, and it enables the reduction of transactions, and the access to the desired information in the desired time (Naralan, 1998).

Generally, IT are used to increase efficiency, minimize costs, and offer higher quality products and services to customers. It provides advantages for organizations in terms of developing information-oriented new products and increasing competitiveness (Nicolis and Tondini, 2006).

It is a fact that the use of IT will get some positivity to the management activities of organizations. In fact, today's management practices have been developed. In addition, the collaboration between the main functions of the organizations has increased, the problems between the functions and branches can be analyzed much better, so it has been adopted organized management philosophy (Öğüt, 2001). In Table 1, it is given the organizations and information systems applications with departments and functions.

The need for information systems that fully support the business activities of the organization is increasing in order to be successful in perpetual competition environment and predetermine the constantly changing business conditions and to respond them quickly (Zhang and Lado, 2001).

Table 1: Information Systems Applications in The Organizations And Information Use

Information Systems	Information Use
Electronic Data Systems	Routine data related with organization activities
Office Automation Systems	Digital data for the operational level
Management information Systems	Information for planning control and decision making at general management level
Decision Support Systems	Intra-organizational and extra organizational graphical information for executives
Executive Information Systems	Analytic information with interactive support
Expert Systems	Top information with artificial intelligence support including expertise suggestions on specific topics

Source: Öğüt, 2001: 101.

2.1.3.2. Information Technology Tools

IT tools are technological elements which are used to process information. Computer, internet, software and hardware, e-mail are among these tools. With the help of these tools, information is received, processed, interpreted, stored, and transmitted.

In this contemporary business, The Internet enables many computer networks around the world to communicate with each other with a common protocol framework and share information resources. Widespread usage of internet formed communication network, which connects many computer systems with each other by TCP/IP protocol. TCP/IP (Transmission Control Protocol/Internet Protocol) enables communication between computers and data transmission/receiving units, so it provides many data communication protocols from one source to another. The Internet is the world's largest communication and information exchange platform. In this platform, communication and information exchange takes place quickly and cheaply (Borriello and Want, 2000). There are three basic services that the Internet provides. These services are; Electronic Mail (E-mail): An electronic message communication system used by many users connected to the Internet to communicate with each other. FTP (File Transfer Protocol): Transfer of large volumes of data files over the Internet. WWW (World Wide Web): It is a service called Hypertext, where texts are offered to users, can be linked to each other by clicking on the items on it (Press, 1993).

Electronic mail (e-mail) constitutes electronic messages sent from one computer to another/others or from one person to another person/persons. With the Internet, electronic messages are delivered quickly and securely to a receiver anywhere in the world with an e-mail address, at minimum cost, within a few minutes (Jackson et al., 2001). The Internet has the world's largest electronic mail (e-mail) network. The message can be sent to an internet user anywhere else in the world via the e-mail service, and it reaches the receiver between a few minutes and a few hours depending on the conditions of the receiving point (Evans, 2012).

If we consider the computer, it is a machine that compares and calculates. In addition, the computer is an automatic information processing tool (Klein and Dologite, 2000). A computer is an electronic tool that processes the given data

according to a determined program, and it can store when necessary, and convey it when desired.

2.1.3.3. Information Technology Systems

In general, IT can provide advantages for businesses such as increasing efficiency, minimizing costs, offering higher quality products and services to customers, developing new products with information resources and in the end, it increases competition. The use of IT has positive contributions to the managerial actions of organizations. Thus, information has directed the behavior and decisions of managers, and it has also improved planning, decision-making and production methods. It has enabled the development of contemporary management methods. Nevertheless, the collaboration among the main departments of the organizations has increased. There have been developments in computer technology in the last 20 years. Therefore, data processing has become faster, more affordable, and reliable. Organizations benefit greatly from IT regarding with their increasing technical capacities, reduced costs and ease of use.

By establishing strategic planning in organizations, businesses benefit from IT capabilities more effectively because within perfect planning implementation on IT, organization can coordinate all processes and overcome the obstacles easily. If the organizations would like to reach their objectives in the long run, strategic planning will be beneficial on sourcing correctly and making significant decisions. Strategic planning is not only helpful for the long-term basis, but also it will help organization to evaluate and analyze external factors. Therefore, every person in the organization should contribute this process related with IT (Öğüt, 2001).

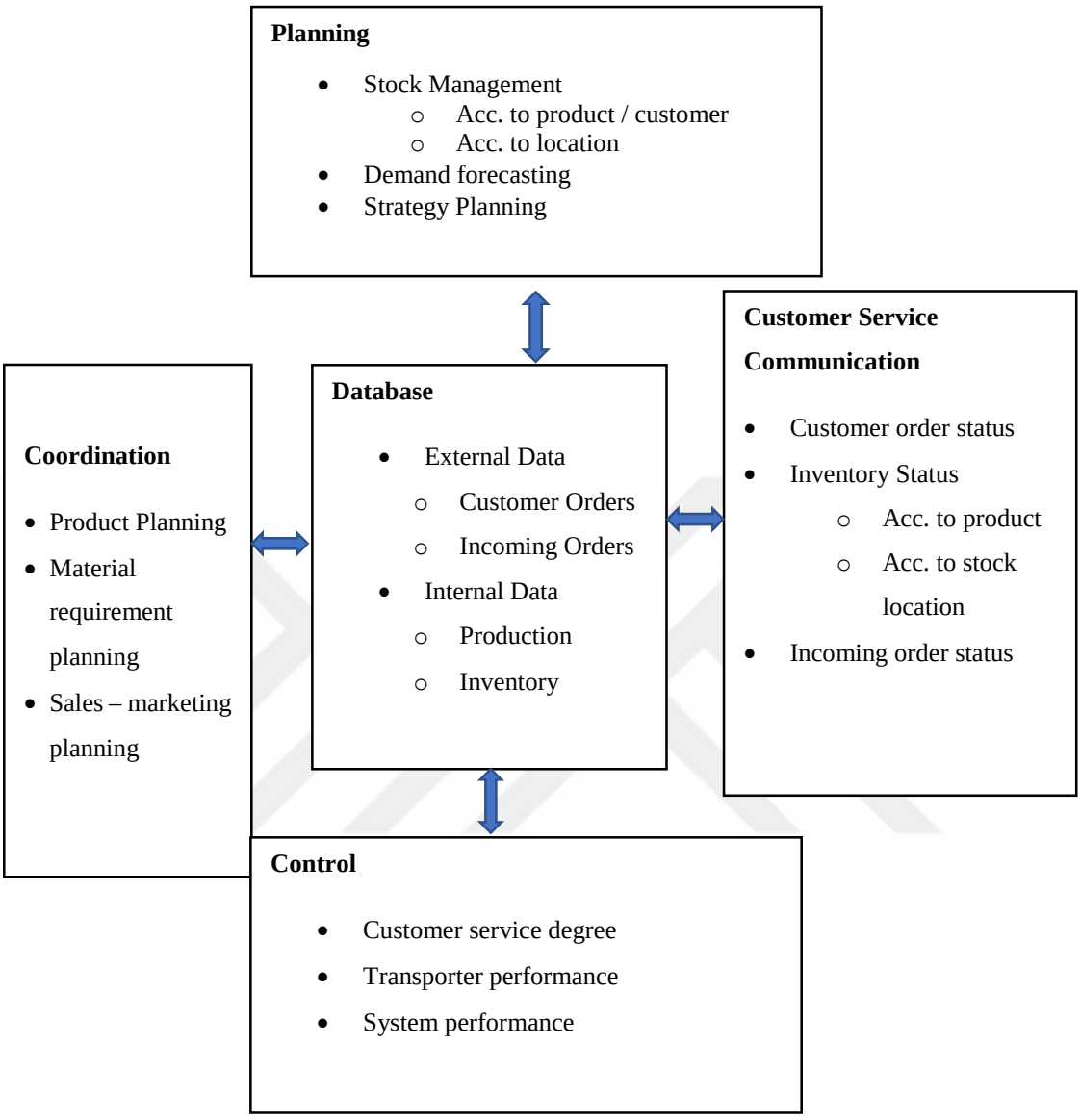
2.1.3.3.1. Management Information Systems

Managerial information systems provide the necessary information flow in an organization. These systems interconnect data from the internal and external environment and provide information and processing support. Management information systems also presents information to the management in a timely and meaningly that will facilitate decision-making process (O'brien and Marakas, 2006).

It is all the activities and systems necessary for the processing, use and management of information as a resource in the organization. In addition, it is a method that enables the planning, control, and operational functions of the organization to be carried out effectively, providing the necessary information on time and accurately to the management in order to facilitate the decision-making process. It is a computer information system that can integrate data from different sources to provide the information. It is a subsystem of the organization's information system in relation to managerial decisions for control and strategic planning. It is all the computer-based integrated information processing methods that can be developed to equip managers with timely and effective information in an organization (Anameriç, 2005).

When organizations build a comprehensive system for arranging their information through the business functions. In Table 2, it can be seen that companies need to have strong database to manage information both externally and internally. In this way, organizations can plan, coordinate, control and arrange the customer service communication via database. While establishing the systems, they pay attention to demand foresight and strategic plans in accordance with their suppliers and customers so as to coordinate the workflow fluently. As a result of it, they can improve the degree of the customer service and the transporters' performances along with the system performance. (Christopher, 1998).

Table 2: Management Information Systems Functions



Source**:** Christopher, 1998: 16.

2.1.3.3.2. Decision Support Systems

Decision support systems are computerized information systems. It supports business and organizational decision-making activities. Statistical analyzes, report techniques, model reports or data base can all be used with these systems. It is an interactive internet-oriented system that solves and identifies problems, using

documents, personal information, and business models. These systems include models, simulations and applications designed to make decision making easier and more effective (Sprague, 1980). For reaching the source of eligible decisions, decision support systems can provide collaborative activities by providing machine – human interaction. Therefore, advanced analyze models will be revealed more detail.

Different decisions are taken at different management levels in businesses. While decisions are made at the operational level are structured decisions. If the approach can be determined in advance when the decision is required, it can be referred as structured decision. If decisions are taken at the tactical level, it can be called semi-structured decisions. If a part of the approach is predetermined but not sufficient, then it is semi-structured decision. Decisions are taken at the strategic level are unstructured decisions. It is not possible to determine a large part of the approach when making a decision here. Decision support systems are computer-aided information systems that provide interactive information support to managers in the decision-making process. These systems use analytical models, custom databases, the decision maker's own views and judgments, and an interactive computer-based modeling process to support semi-structured and unstructured business decisions. Therefore, these systems are fast-response systems designed for a specific purpose that are initiated and controlled by decision makers in organizations. Decision support systems directly support certain types of decisions, personal decision-making style, and personal needs of middle and senior managers (Hersh, 1999).

2.1.3.3.3. Office Automation Systems

The use of computer technology to automate normal office processes and duties is known as office automation. Individuals, groups, and organizations can use office automation systems to gather, process, record, and transfer electronic messages, documents, and other types of communication. (Olson and Lucas, 1982).

With the use of office automation systems, information flow between organizations is accelerated and costs are reduced. Reducing costs is the primary goal of organizations. Therefore, with the reduced costs, organization’s operations performance will be improved.

The use of computer technology in offices to carry out work and transactions more effectively and promptly is referred to as office automation. In other words, office automation is the use of information technology to streamline labor and processes by changing employee workstation layouts and enhancing efficiency (Al-Mamary et al., 2014).

In this context, office automation systems can be defined as computer-based information systems that allow people, groups, departments, and functions to receive, process, save, and transfer all types of electronic messages, documents, and other communication formats (Yang and Peng, 2001).

Office Automation Systems is an information systems application that aims to increase the productivity of employees in the office. Office Automation Systems control different information workers, geographic and functional regions. It accelerates communication and contributes positively for the efficiency of employees by ensuring that the activities and transactions carried out in the offices well organized (Altınöz, 2008).

2.1.3.3.4. Expert Systems

The emergence of expert systems is considered as the latest software type that is formed as the basis of knowledge engineering. These systems have their own principles, tools and techniques which depend on the subject.

With the increasing role of expert systems in the business, mechanisms are emerging that can instantly analyze the market and the needs of the market. These mechanisms not only face with instant problems, but also evaluate the problems that the business may encounter in the future and seek ways to stop these problems before they become apparent (Erçetin and Baykoç, 2004).

Research on artificial intelligence in recent years has led to the popularity and development of expert systems. It has been observed that the results obtained in platforms where expert systems are used are very close to the results obtained by human judgment. This technology has been successfully applied in the fields of organic chemistry, medicine, industry, banking, and mining. Expert systems are used as an automatic decision element, as well as a decision support element in complex

problems. Expert systems are also used successfully in fields such as data interpretation, diagnosis of errors and diseases, structural analysis of complex objects, design of complex and planning sequences of operations (Alberico and Micco, 1990).

2.1.3.3.5. Electronic Data Processing Systems

As term electronic data processing systems are not used frequently nowadays. It is mostly referred as information services or management information systems. Electronic data processing systems were derived from the computing physical forms like punched cards or other paper reports (Auerbach, 1961).

It is the sharing of information between different organizations with the computer and its standards, structure, and machine structured. In the previous times, it was used to exchange the information with suppliers without using paper. Electronic data processing systems are not only useful but also fast. Although the electronic data processing has a limited capacity, it is still efficient and can both meet the needs of some companies and save time. Electronic data processing systems are not only useful but also fast. The inadequacy of electronic data processing systems means loss of time, loss of effort, and loss of speed for organizations. In addition, this inadequacy will result in the employment of extra personnel. If it is considered that the error rate will be high for manual work, these errors will cause additional costs for organizations.

2.1.4. The Development of the Use of Information Technologies in Businesses

Today, organizations can compete, and they can be successful as they can harmonize information and IT within their organizational structure. Opportunities provided by information technologies offer organizations both significant advantages and disadvantages. In today's world it has become more difficult than ever to meet customer demands and ensure customer satisfaction. The spread of information in the world generates a competitive environment with increasing economic welfare and free trade opportunities. These developments create a positive competitive advantage for those who can create knowledge and adapt to change in today's world (Turunç, 2006).

The development of the use of IT in organizations is researched in terms of periods. These periods are information processing, micro processing, and network. Between the years 1960 – 1980, there was direction towards industrial products which supported mainframe computers. The main objective of the computers to be used in organizations were providing automation of lower-level management affairs and in-plant affairs. In the organizations the demand for mainframe computers began to drop since the mid-1970s. As companies began to increase their demands for computer systems that could benefit middle managers, the computer industry directed to this field (Eccles and Nolan, 1993).

The decrease towards mainframe computer systems and the need for mid-level managers to benefit from computer-based applications have led new searches in the computer industry. The reason is; the need for computer applications of middle-level managers was different from the need for computer applications of lower-level employees. In this period, the attempts of middle managers towards automation were a failure due to the factors such as hardware and software (Spreitzer and Quinn, 1996).

At the beginning of the 1980s, the use of micro-process technology, information technology was aimed to be used by intellectual labor force. The new paradigm was information rather than automation by developing to meet the needs of middle-level personnel. The purpose of informing, unlike automation, was to increase the efficiency and productivity of employees rather than using computers instead of personnel. The purpose of informing, unlike automation, was to increase the efficiency and productivity of employees rather than using computers instead of personnel. As a result of the widespread use of micro-processed systems, the middle level managers had decreased over time (Engin, 2015).

In this period, it was seen that personal computers became widespread. Development of micro technologies, microprocessors are used in almost every product, from consumer electronics to automobiles and credit cards.

With the automation of management and in-plant processes in the periods of data processing and micro processing systems, improving the knowledge of intellectual labor force and developing some products and services are the main reasons for demand towards computer related fields. By using information technologies, organizations want to get competitive advantage, so they rebuild their

organizational structures and set up strong network systems. It is estimated that the use of information technologies will lead to a tenfold increase in productivity if employees and jobs are organized in the form of a network. In network structures, projects will be carried out by cross-functional groups and the boundaries of traditional departments will disappear. A networked organization would enable the execution of firm activities and projects by multidisciplinary groups. The trend is going through the use of interorganizational networks that connect more than one organization. Interorganizational networks are systems that connect a firm's wide and local area networks to the networks of its customers, suppliers, information service businesses, and other organizations (Provan et al., 2007).

The effects of both local and wide area networks can be used in many platforms. The rapid and effective communication of the personnel in all units within the company access to databases easily. In addition, interactive information exchange over the network with competitors, contractors, and customers outside of the company brings together many organizational and sectoral differences (Baker and Faulkner, 2017).

2.1.4.1. Effects of Information Technologies on Businesses

Changes in production, business profitability, and consumer surplus are three methods used to calculate the value of information technology. The relationship between IT and firms is assumed to be an indirect and hard-to-calculate, yet it is a complementary relationship. The complement concept often defines the production paradox in observing diversity in IT and business value (Schryen, 2013).

The productivity paradox sheds light on the changes in the findings on IT investments and production topics. Production is the calculation of output rates, manufactured product, outputs, raw materials, and labor costs. If IT have a negative impact on production, less output is expected rather than the same level of input. Information technology constitutes the possibility of lower cost of raw materials and increases the price of output per worker. The collaboration of production and information technology is more profitable. The various research shows that there is a profitable relationship between information technologies and investment. However,

there is not necessarily a positive relationship between diversity in production and information technologies. The use of information technologies does not directly provide production gain. When the production is analyzed, it is very difficult to determine the effect of information technology investments on inputs and outputs. Approaches for analyzing information technology value are being developed to analyze the impact of information technology investments on financial performance (Schryen, 2013).

As the IT support the organizations' operations within all aspects processes, organizations can compete and adapt the business dynamics easily. In this information era, organizations need use these technologies to a large extent in order to continue their operations in the markets.

2.1.4.2. Security in Information Technologies

In each organization, there are risks in terms of information technologies, and these are argued in many ways. Managing risks in information technology is about not paying too much attention to the links between organizations. Beyond the scope, many sources discuss information technology risks, potential threats, probabilities of success, and impacts to organizations (Finch, 2004).

The determination of security system infrastructure and policy for the information security is very crucial for the organizations because information needs to be well protected. Therefore, security management must be conducted both completely and accurately. After determining the security system infrastructure and policy within information security, it needs to be done the analysis of the information, then security management should be executed accurately and technically. After that, it needs to be determined the negative factors towards information and system security, so organizations take control of the process by analyzing even with low levels of information.

As the security of information has the dynamic process, there should be both protection and consolidation. Consequently, this process needs preparation and after the attacks towards information security are detected, it is necessary to step in quickly, so the system should always be improved with this way.

In the modern world, the tendencies to use computers and the internet are increasing day by day, and it affects our lives more and more. In addition to the returns, benefits, gains, and positive aspects of the virtual world, in case not taken care, threats towards information security will disrupt personal and corporate functions, and it will cause great damages both locally and globally (Canbek and Sağıroğlu, 2006).

2.2. THE IMPACTS of INFORMATION SYSTEMS on SUPPLY CHAIN

The main objective of IT regarding SC is to link between point of origin and point of consumption. In this point, having correct information to track and trace the information correctly. Thanks to today's developing information technologies, the spread of information among the SC partners has become faster and more effectively, and the cost for this has decreased significantly.

Organizations execute their planning levels within real data, in this way, they track and trace their delivery schedules effectively. Each member who takes part of this SC structure can reach that information easily. In SCM, thanks to IT, first organizations gather the information, then it needs to be analyzed. Lastly, information should be shared withing the framework of collaboration among SC partners.

Using IT enables customers to access their order status in SCM. Moreover, by using IT, the SC members gain huge advantage on their profits in terms of time saving their time, labor, and resources. Consequently, there will be customer satisfaction with their high level of service.

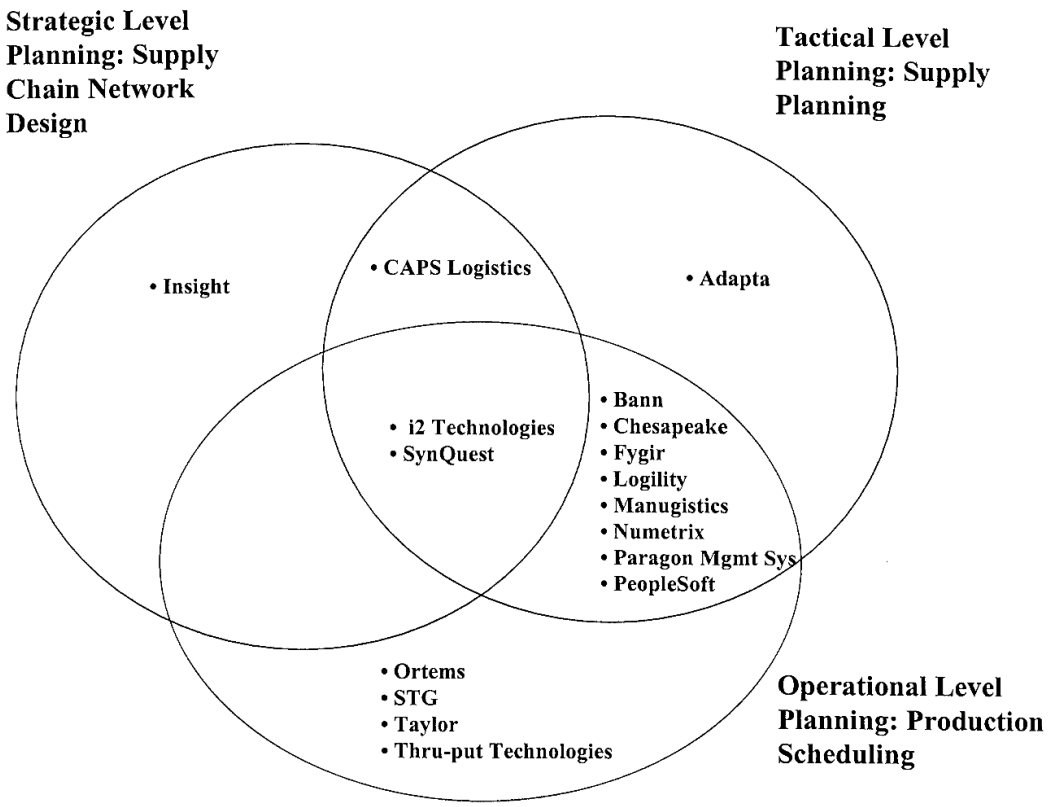
Accordingly, companies competing in both domestic and foreign markets have to improve their existing SC, if it is necessary, even they can restructure it by considering market conditions. Therefore, organizations benefit from IT to cope with those competitive market conditions. As it is mentioned above, the systems used in SC process should be very comprehensive because they support any kind of workflow from stocking to transporting the products.

Consequently, it is necessary to develop flexible business processes that can easily adapt to changes in the market. Many systems or software packages integrate business processes from supplier to customer and manages a number of tasks such as sales, production, logistics and finance.

2.3. INFORMATION SYSTEMS USED in SUPPLY CHAIN MANAGEMENT

IT have a critical role in the planning and implementation stages of the SCM. There are three stages in IT which effect the SCM process, these are strategic planning, tactical planning, and operational planning. Information technologies have a critical role in the planning and implementation stages of the SCM (Talluri, 2000). In Figure 7, it can be seen that establishing correct system is crucial for organizations because of their capabilities level. There are large quantities of data, and the usage of information can take part strategical, tactical, and operational ways.

Figure 7: IT/IS Vendors for SCM Planning Phases



Source: Talluri, 2000: 224.

Information technology is not just about the internet, it also includes various systems and software. Technologies that are mostly used to share and evaluate data within the SC: Enterprise Resource Planning (ERP): Warehouse Management System (WMS): Radio Frequency Identification (RFID): Order Management System (OMS):

Electronic Data Interchange (EDI): Transportation Management System (TMS): Vehicle Tracking System (VTS): Inventory Management Systems. These technologies, which are used to increase the efficient and effective use of SCM, are explained below.

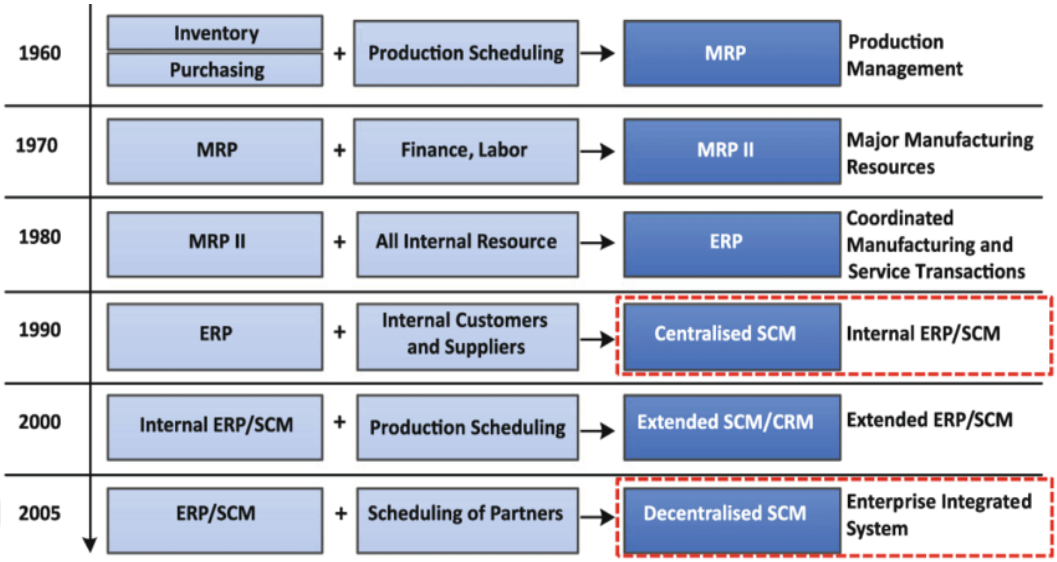
2.3.1. Enterprise Resource Planning (ERP)

Enterprise Resource Planning (ERP) is a software program that provides all data exchange of workflows in the organizations. It is software package and covers all the functions of organization (Klaus et al., 2000). Enterprise resource planning, which has an extremely important place in businesses today. In the direction of the strategic goals and objectives of the organizations, ERP can be defined as a communication system which is the most suitable and appropriate link between all functions of the entire organization. Enterprise resource planning communicates all units in the organizations with each other, and it is based on information sharing (Dezdar and Ainin, 2011).

Planning, procurement, production modules and information are integrated with other systems in ERP applications. ERP was developed based on the Material Requirements Planning (MRP) application which is used to plan material needs. However, after some issues on the applications MRP and MRP II, some solutions have been found with ERP applications. In addition to other previous applications, ERP includes the functions such as accounting, finance, human resources, distribution, decision support, research and development, maintenance and repair support, quality control, health and safety (Boersma and Kingma, 2005).

In Figure 8, it is given the development of ERP within the management of internal and external sources, and it is also shown information flow. It is significant because SCs enable the delivery of goods to geographically scattered areas in the appropriate quantities, in line with the relevant standards, at the right time, and at a reasonable cost (Mourtzis and Doukas, 2013).

Figure 8: Evolution of supply chain management and ERP



Source: Mourtzis and Doukas, 2013: 360.

Considering the current trading platform used by companies, ERP solutions enable different software to work in an integrated manner, both inside and outside the organization. In addition, the ability of distributors and suppliers work together with the main company, as if they were a single company, is one of the goals achieved by the new generation ERP solutions. Thanks to information technologies, this system can be supported.

In this point, it is better to explain with an example, when supplier register the order once, then the process begins. It is transmitted electronically production planning section, sales and other suppliers without the need to start the entire order processing once again. Consequently, it can be easily said that this integrated work cycle can increase the performance of the whole supply chain members with information sharing. The integration of SCM and ERP has become a natural process for the continuity of organizational capabilities.

2.3.2. Warehouse Management System (WMS)

In the SC, inventory is one of the main components, so organizations need to decide where to stock with low costs, with proper conditions and with infrastructures in where stocks can be moved swiftly (Ramaa et al., 2012).

WMS are the systems that are used to monitor and control the stock movements in the warehouses during the process from taking the products into stock to shipping. With the warehouse management system, warehouses can be organized and monitored, so it is easy to manage all warehouses with a central system, and it can be also recorded and controlled in and out movements of products (Van den Berg and Zijm, 1999).

Thanks to WMS, operations in warehouses can be carried out error-free and fast, so the efficiency and productivity levels of warehouses can increase. Warehouse management systems are used to plan and manage the movements of raw materials or products in the warehouse. Systems organize the processes of determining the most suitable stock location, ensuring the fastest distribution, transferring between warehouses, and counting stocks regarding with the dimensions determined for the product (Richards, 2017).

When the main advantages of the warehouse management system to the organizations are evaluated, it can be seen that the decrease in the inventory level, increase in labor force productivity, improvement in shipping accuracy, inventory accuracy at each location, increase in order fulfillment rates, reduction in direct operating costs and increase in overall income.

2.3.3. Radio Frequency Identification (RFID)

Technology-based innovations in the products/services offered by organizations lead to significant changes in the business processes. Radio Frequency Identification **(**RFID) is technology that use radio waves for automatic identification of different materials. RFID technology provides the basis for a new coding system, as well as helping businesses to solve the problems they face in controlling their supply chains. It is mostly used to solve the problems caused by the lack of information in the

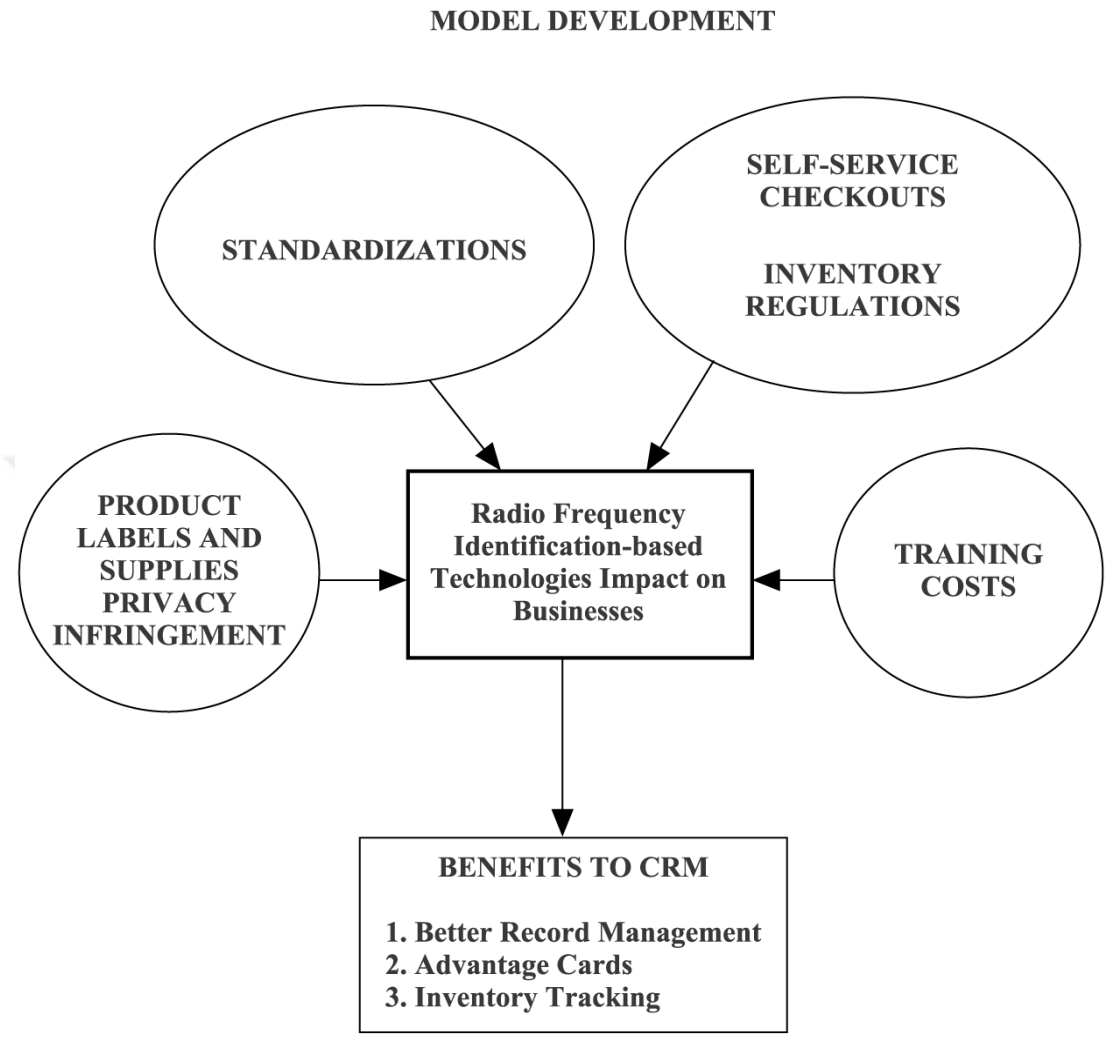
supply chain. Especially, with the integration of WMS, it can be highly benefitted (Chen et al., 2013).

Radio frequency identification allows users to collect information with wireless technology from electronic tagged files. Radio frequency identification includes software, network, and database components, and it ensures that the infrastructure of the information is transferred to the company. The systems contain special applications. Some use passive, low-cost tags with short reading sequences, so most information in the network and few information tags are used. Others access high information capacity with sophisticated, high-performance tags, or read orderings even without a network connection (Saab and Nakad, 2010).

The areas where RFID are mostly used product distribution chain applications, inventory management, production, accounting and auditing, medical field, security applications and in many various sectors such as in the tracing of information records on product features and maintenance, in the smart card applications, in procuring, in transportation (container and baggage information tracking): in public transport, in the production of valuable products and monitoring of those products (Kavas, 2007).

In the context of the SCM and logistics activities, in the beginnings, RFID provide beneficial and new technological advances for the retail industry by significantly reducing costs. Today, the usage area of RFID technology is expanding day by day for the logistics sector. It can be used effectively from controlling the product tree in production to warehouse management. The effective use of RFID prevents receiving products, manual counting, and other activities manually. Thus, the inventory control of the received products and the stored product in the warehouse becomes easier (Smith, 2005). In Figure 9, the model is illustrated for RFID technologies and impacts on CRM and business all business operations.

Figure 9: Development of a conceptual model exploring the interrelationships between RFID-based technologies and CRM



Source: Smith, 2005: 25

It can be easily understood that many benefits can be achieved with RFID technologies in SCM. These benefits are reduction and predetermination in delivery times, reduction of repetitive work process, reduction of errors and labor costs because of automation of processes with combining labor force, to be able to take precautions against problems that may occur in the SC by obtaining detailed information about the product from production to the point of sale, ability to respond to changes in the SC immediately and improving the customer service functionality (Sabbaghi and Vaidyanathan, 2008).

2.3.4. Order Management Systems (OMS)

The starting point of logistics operations and supply chain process is ordering process. During this process, marketing and sales order integrity helps to complete this process. It can be easily declared that customer service quality and customer satisfaction depend on how this process can be conducted successfully. By having orders from customers, organizations need to plan their service capabilities. Thus, the preparation points such as receiving order, processing, and transferring order and sending information to customer can be performed by having OMS (Berlak et al., 2001).

By using order management systems, organization have lots of advantages on their SCM operations. Some of these advantages, organizations can shorten their cycle time in their logistics operations, there will be less variable in the order process, organizations can easily control order tracking, as the organizations can minimize the error rates because of the customers, order fulfillment rates can be achieved, and they can increase the degree of customer satisfaction easily. Consequently, organizations achieve flexibility on their business activities.

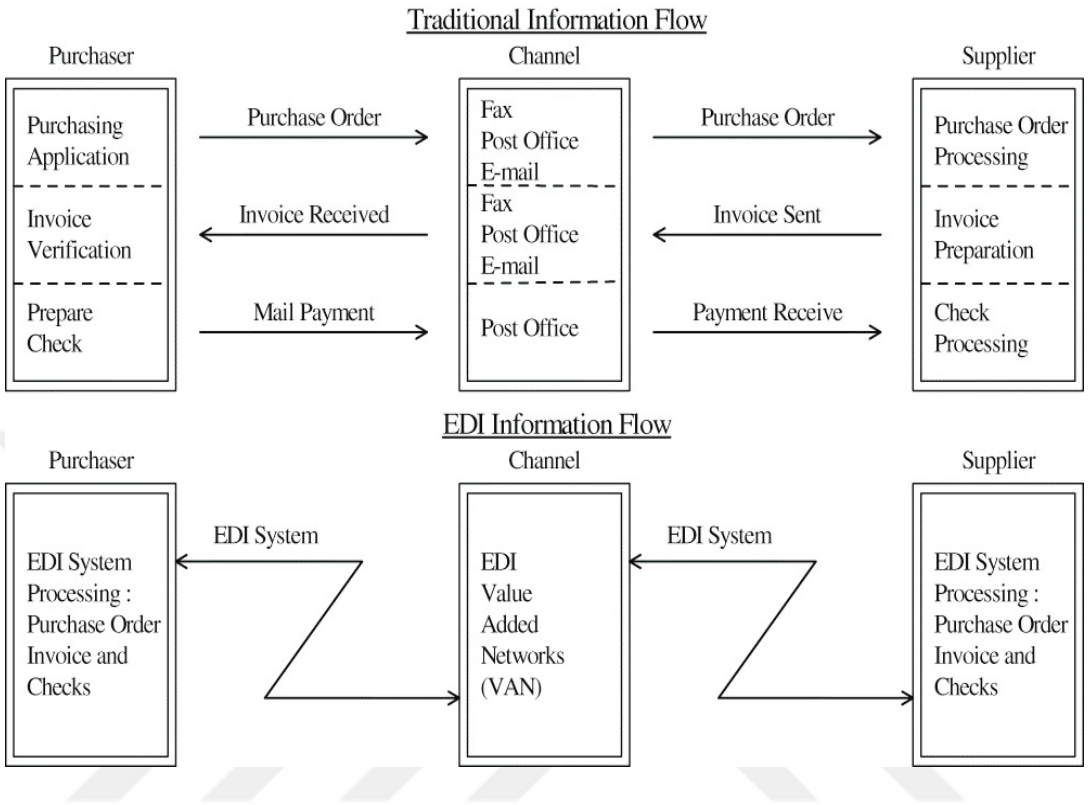
2.3.5. Electronic Data Interchange (EDI)

Electronic Data Interchange (EDI) is the system that transmit information between organization or departments instead of using mail, fax, or other communication tools (Klapita, 2021). There are many transactions via EDI, information sharing between partners, purchasing orders, documentation, carrier information and remittance forms (Lee, 2000).

In general, by decreasing paper use in business activities, there is an accuracy on the business transactions. Thus, the speed of transactions and purchasing possibilities increase and the costs are dropped. It also shortens the time for delivering the product to the customer (Ramdeen et al., 2009; Chopra and Meindl, 2001).

In the Figure 10, the comparison between traditional information flow and EDI information flow are presented. Each flows shows the transactions systematics through the functions.

Figure 10: Traditional and EDI Information Flow



Source: Ramdeen et al., 2009: 271.

The use of EDI requires special telecommunication systems and standard forms. It is strictly secured system, so it is only available to registered users. However, hardware and connection costs of this system is expensive (Agi et al., 2005). At first, large companies used these systems for their accounting and payment transactions. Then, it began to be used not only for accounting, but also for production, management, and in other fields.

EDI supports changes based on competition such as quick response to customer demands or just-in-time inventory management. With the assistance of EDI, businesses exchange information and activities in a short time. It is also possible to do some transactions by using EDI such as sharing information about production and delivery schedules, predicting stock levels, and forecasts on business requirements.

Particularly, small, and medium-sized businesses nowadays give opportunities to perform their business activities with cheaper technologies (Gunasekaran, 1999).

EDI is one of the first systems used in SCM, and it was integrated into the processes reducing the time to fill empty shelves in different stages of SCM. Therefore, it reduced the delivery time significantly regarding ordering with other digital forms of communication. In addition, thanks to EDI and barcoding, the accuracy and speed of information transfer have increased. (Roadcap et al., 2000; Chopra and Meindl, 2001). As the information sharing is the crucial among SC partners, EDI increases the dynamism of SC system performance, so at the end, it will highly affect the relations of SC members.

2.3.6. Transportation Management System (TMS)

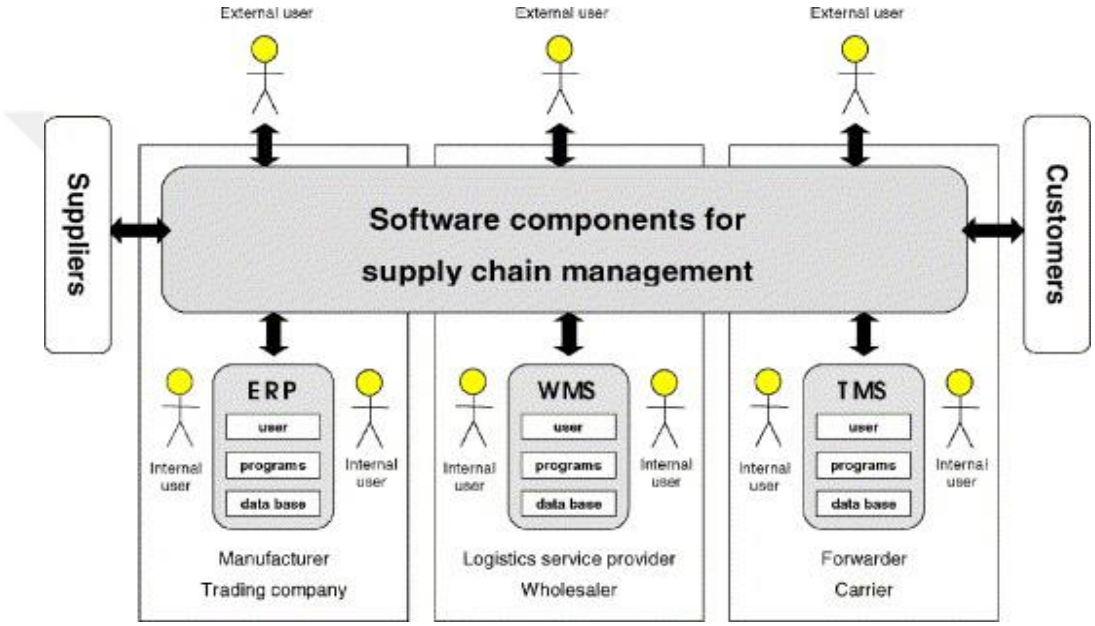
Transport management systems (TMS) form a big part of the logistics operations, these operations include arranging transports for order process, during this operation planning the route, monitoring the transportation activities in and out movements are essential for the TMS. The significant points of these movements are optimization and planning. As the TMS depends on a database, it is easy to integrate all sub-functions of TMS. In the planning phase, some operations are needed to be arranged such as whether the products will be carried with the same vehicle or not, and before going to its destination vehicle stops by in any point or so. In the optimization process, routing and optimization of vehicles are two options for the operations. In this process, the required vehicle can be adjusted in accordance with the need of partner. In the end, two phases are integrated to transportation management stage in which the managers can track and trace the vehicles, getting necessary reports and informing the management. It can be easily declared that TMS are more successful and effective when they are combined with other systems (Helo and Szekely, 2005).

With the increasing e-trade standards and application fields, customer expectations also have changed towards just-in-time delivery services and high flexibility in the transportation operations. For the SCM process, the logistics activities, especially transportation operations are crucially significant as the organizations develop their logistics operations in order to compete. At this point,

organizations are expected to benefit from IT regarding their fleet management. The reason is, IT connect all the different functions such as vehicles, equipment, or management process in the transportation chain. Thus, the efficiency and productivity of transportation operations increase (Kalkan and Kalkan, 2016).

In Figure 11, it is given the functions of IT in SCM when TMS is used with other technologies

Figure 11: ERP, WMS and TMS in the Supply Chain Management Architecture



Source: Verwijmeren, 2004: 168.

In the figure, IT within the SCM has the systems ERP (Enterprise Resource Planning): WMS (Warehouse Management System) and TMS (Transport Management System). Each system has its own functions to work efficiently. ERP system contains procuring, sales and materials management with trading companies and producers. WMS includes order picking and receipts operations with logistics service providers and wholesalers. On the other hand, TMS embodies transportation planning and monitoring with carriers and forwarders (Verwijmeren, 2004).

Consequently, the aim of the TMS is to optimize the delivery services and cycles by reducing transportation times and costs. In order to implement these

activities, it needs to track the synchronization of vehicles and shipments, then informing the customers to draw up strong customer relationship (Drexl, 2012).

2.3.7. Vehicle Tracking System (VTS)

In general, Vehicle Tracking Systems (VTS) have a modular structure. These systems are formed by integrating many different functions and technologies. Global positioning module, wireless communication, digital maps, map matching, and user support software route planning are some of the modules. Depending on different needs new modules can be added or removed from these modules. Information of object positioning is obtained with the help of the tracking and positioning module attached to the moving vehicle. After the location of information is obtained, the data package containing the location information is transmitted to the tracking center with the help of the wireless communication system. Position information transmitted to the tracking center, and it can be tracked on a digital map and the vehicle can be guided if necessary from this center (Antonelli et al., 2004).

The positioning module can use two different techniques for position detection. The first one is the satellite-based Global Positioning System (GPS): the other one is a position determination method based on a certain reference with the data obtained from receiver tools such as compass or accelerometer which depend on the movement of the vehicle. The road planning module is another module that constitutes vehicle tracking systems. Road planning determines the route of the moving vehicle with the analysis made on the digital map and informing the users in real time to find their way. Traffic information and reports can also be integrated into this system. Thus, users can find the most suitable route automatically (Hua et al., 2018). Apart from GPS, Geographic Information System (GIS) is also used with VTS.

VTS has the advanced technologies, and with its this structure, it will continue to develop regarding technological innovations termly. For instance, Fleet Management Systems have been developed to monitor and direct the vehicle fleets of companies with more than one vehicle. Moreover, with VTS based systems; monitoring, guiding and management of traveling vehicles are provided such as school buses, couriers, vessels, or planes. Therefore, this technology can serve in such a wide

and very different range, and in each stage a different structure is used in accordance with the purpose (Doğru et al., 2006).

Hence, the adoption of a new technology is related to the understanding the application is both necessary and useful, accordingly traceability and SCM should be comprehended well by the organizations for using onto their systems. Especially, in some sectors like catering, it should be start using IT that allow traceability, and organizations must respond to consumer demands by making their SC processes transparent (Keleş and Gülden, 2022).

2.3.8. Inventory Management System

Inventory management is crucially important for organizations, and it is one of the components of SCM. Inventory management covers to store and flow the goods, services, and information from production to consumption. As it is part of the SCM, organizations must plan this process efficiently and effectively for both implementing and controlling the product and service flow. Forward and reverse operations can be conducted during the operations for meeting customer demands. With the help of inventory management systems, organizations should avoid themselves from excessive oversupply (Singh and Verma, 2018).

The structure of inventory management systems in the SC has changed over the years. There are many reasons behind these changes, apart from the changes on customer demands, there are also changes in every period, in each sector, and for every SC member. In this part, it will be explained some significant inventory management systems used by different organizations from various sectors.

Collaborative Planning/Forecast/Replenishment (CPFR) is one of the systems that can be used for controlling inventory levels. The system was first used by Walmart American retail giant. Then, it is developed to coordinate the operations from production to inventory levels in terms of collaborating among SC partners. Basically, the system starts with the trust and information sharing between the SC partners, then it continues to improve forecasts on demands, lastly, both purchasing and production strategies along with inventory replenishments are formed by the partners (Kurnia et al., 2015). As the system focuses on inventory, product life cycle, retail trends and SC

cost structure are main concerns for CPFR. In particular, CPFR fits for almost every sector, yet it is largely used textile, food, and retail sectors. From upstream to downstream, it encourages partners to share valuable information as it focuses on some procedures and standards in terms of forecasting on sales and orders among the SC partners (Panahifar et al., 2015).

Vendor Management Inventory (VMI) is another system related to inventory activities which is controlled by suppliers. The system focuses on the partnership and increase the performance of SC. It is one of the favorite systems used by the retailers Home Depot and Walmart. When the supplier gets the data, VMI starts working by showing the sales and storage information of partner. After partner can check every transported product by supplier, partner or manufacturer plans for the storage and production. The objective is, suppliers don't focus on ordering anymore, producer or partner starts order process. With this system, it is possible to diminish the issues related with bullwhip effect which covers serious inventory problems. Therefore, VMI system doesn't change the level of stock (Dong and Xu, 2002; Sari, 2007; Govindan, 2013).

Quick Response (QR) is another technology used by organizations to optimize their stock or inventory levels. The technology was firstly used in apparel sector in USA. After using QR technology, the process of procurement period from raw materials to the consumers were minimized. Before using QR system, orders were spending time either in warehouses or transportation period. Therefore, long SC processes lead many problems such as product missing and other funding issues. For effective inventory management QR provides information sharing among the SC partners, and it concludes customer satisfaction. Especially, in retailing industry the system is very popular if there are so many partners it needs to be worked with. By implementing QR system it is possible to increase the inventory profitability in terms of having material information in real time when it is required. QR also embodies sales of data and discounts for distribution schedules (Fernie and Azuma, 2004; Choi and Sethi, 2010).

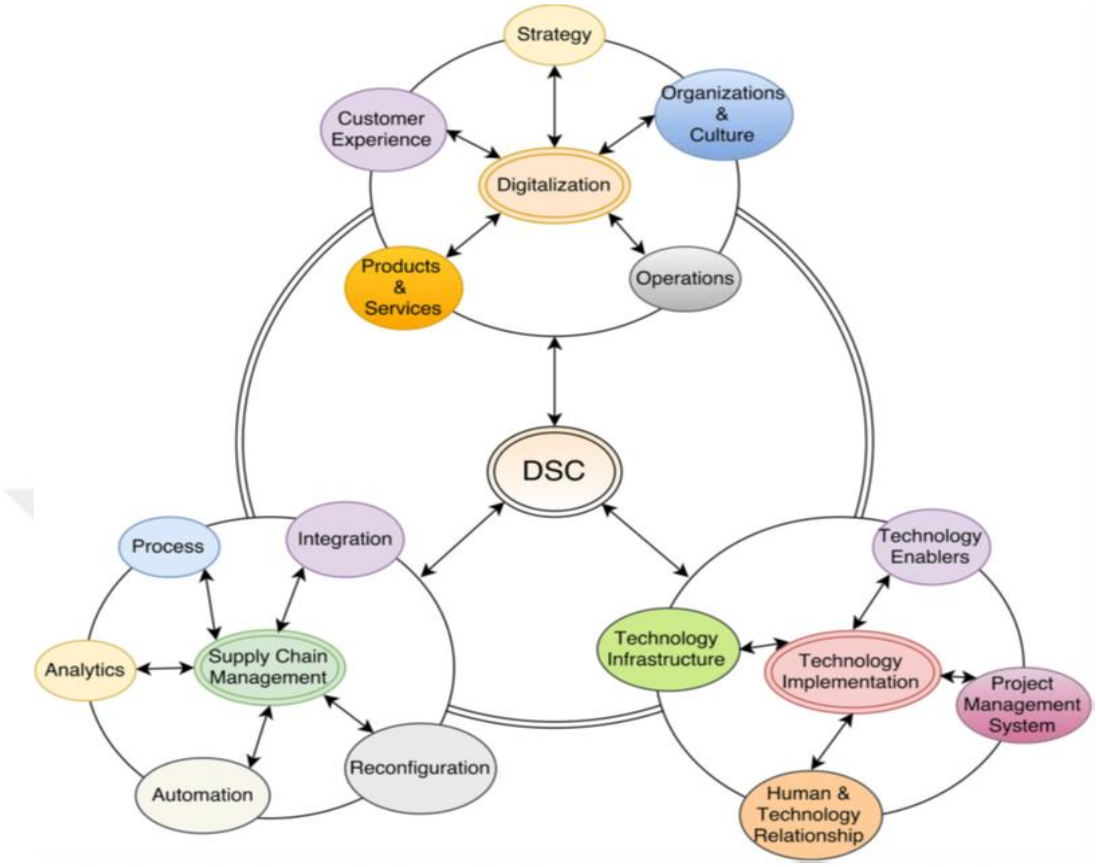
2.4. SMART/DIGITAL SUPPLY CHAIN

Smart Supply Chain (SSC) or in accordance with other academics Digital Supply Chain (DSC) is both designed and organized to increase the efficiency of logistics operations, production capabilities, distribution levels, and other related activities via the internet or other services or systems. In fact, SCM always needs a systematic structure. As mentioned before, communication among the SCM partners, carrying out strong collaboration with them, planning resource management, controlling the operations strategically planned and flexible related to strong system concepts (Ataman, 2002).

With the emergence of Industry 4.0 which is one of the important subjects in contemporary business, organizations have started to transform their systems into smart or digital approaches in order to improve their SC performances because the dynamics of Industry 4.0 focus on digitalization. With aspects of digitalization, societies, organizations, and human life have been all affected (Yılmaz and Duman, 2019). Therefore, organizations use cost-effective, accessible and valuable methods on their SC operations as they adopt digitalization. During the transformation from traditional SC to digital SC, organizations mostly focus on information sharing in order to manage their SC activities with their partners more effectively and efficiently. Hence, they are able to manage their operations with IT via digital platforms, so organizations can carry out both their business transaction automatically and integrate their operations digital platforms by coordinating the process from their suppliers to end-customers (Büyüközkan and Göçer, 2018; Özan, 2022).

The concept of SSC is not formed with a simple business cycle model or flow diagram, today in businesses there is complexity and organizations need to adopt themselves advance transportation, technologies, digital media platforms and most significantly internet services. The reason is using virtual materials in operations have become more and more recently in SC. Industry 4.0 provides many opportunities to organizations to manage, track and optimize their business processes digitally; for instance, Internet of Things (IoT) which will be explained later, is one of the web-based platforms to provide real time data to organizations (Abdel-Basset et al., 2018).

Figure 12: Integration framework for the development of Digital Supply Chain



Source: Büyüközkan and Göçer, 2018:171.

In Figure 12, it can be seen the evaluation of DSC. DSC is located at the center of SCM, digitalization and implementation of the technology, so they all focus on the performance of SC partners considering with increasing both profitability and productivity of the SC. Each stage has its own structural segments and given in detail. As it is obvious that each SC segment is given with different purposes regarding the organizations approaches for their requirements. DSC gives organizations opportunities to increase their SCM performances by increasing reliability, productivity and agility with highly accessible information and strong collaboration factors. Therefore, today many organizations have started to invest on their digital aspects of organizational structures and DSC programs (Wu et al., 2016; Büyüközkan and Göçer, 2018). In the next part, the technologies used in DSC / SSC will be explained.

2.4.1. Technologies in Digital/Smart Supply Chain Management

Industry 4.0 has come with a lot of new technologies to functions of business. With these evolving technologies, new business models, digital products and services, smart manufacturing systems and digital supply chain approaches have been come to light. It can be easily said that the new digital business ecosystem has improved the value chains, customer related subjects and partnerships in the sectors (Ibarra et al., 2018).

It can be easily defined that DSC is the platform where suppliers simply share information in terms of strategic and operational ways. Therefore, sharing information takes place among the partners of supply chain system regarding design of a product or service, research and development, manufacturing, the design of procurement process, and finance. In general, internal coordination takes place through electronic links via IT. Hence, the system provides an automation which covers payment at the source in a digitalized method. This business flow in DSC embodies not only a business cycle processes, but also an extremely large information sharing, including a large environment from social media applications to IoT. The technology of SC is formed by modules which are already integrated within the SCM. This information technologies emerge as the most critical driver of the business cycle (Korpela et al., 2017).

IT in DSC have a role beyond the critical driver of the business cycles. Factors such as the integration of business processes holistically in the DSC, reduction of management costs, and the sharing of the cost burden of business processes among other partners in the system are seen as the main motivation of the digital chain (Shao et al., 2021). The important detail to be considered in this regard saving the costs related with IT while having newer, larger, more accurate and just-in-time data. This situation has the potential to turn into both an advantage and a disadvantage. If big data can be converted into automation correctly, it is possible to minimize physical human-made data entry errors. Although it is generally accepted that B2B integration supports the more effective management of SC processes, it is observed that the low performance of the current system's mutual work causes high investment costs. On the

other hand, by establishing smart technologies, organizations have chance to design and manage their SC structures easily while minimizing costs and sharing risks. Thus, organizations focus on real time data to take the decisions faster and more accurate in terms of meeting customer requirements (Juhász and Bányai, 2018; Wang et al., 2016).

The technologies within DSC and Industry 4.0 have the similar features as they both focus on important technologies in accordance with the characteristics of the sector. Internet of Things (IoT): Cyber-Physical Systems (CPS): Big Data (BD): and Cloud Computing (CC) are some of the significant technologies used during the DSC processes.

2.4.1.1. Internet of Things (IoT)

The Internet of Things (IoT) can be defined as a worldwide network formed by uniquely identified objects, and the objects in this network communicating with each other with a specific protocol. It is also possible to define it as a system of devices that communicate with each other and form an intelligent network by connecting and sharing information thanks to various communication protocols. Thus, objects are easily transmitted via computers, RFID tools, smart phones, or other hardware by using internet and other software systems (Şekkeli and Bakan, 2018).

IoT affects whole Industry 4.0 elements: smart factories, smart manufacturing operations and smart logistics activities. When the objects consist of digital features, those objects can be traced and tracked easily by the integrated systems. Therefore, IoT technology provide SC partners to manage operations and quality elements considerably Abdel-Basset et al., 2018). There are so many benefits of IoT technology to logistics operations. For instance, many activities inside the warehouses can be monitored easily, and the issues such as excessive handling and storage activities or losses can be minimized. It is also possible to combine IoT with RFID tools as it provides user some guarantee period, expiry date or sales data about product to SC partners. Transportation data can also be share by the chain partners, they can easily reach routing schedule, terms or agreements related with shipping easily while transporting the goods (Landaluce et al., 2020).

In addition, IoT is used to detect the potential issues of business processes and it supports to optimization of facilities easily. Therefore, it supports the sustainable actions of organizations by reducing carbon footprint with smart materials on the products. The data obtained from these products can be used to comply with the regulations on the green mentality projects. Consequently, it can be easily explained that for building green SC structures, organizations must focus on such smart components by using IoT technologies (Manavalan and Jayakrishna, 2019).

2.4.1.2. Cyber Physical Systems (CPS)

A Cyber-Physical System (CPS) is a computer system in which a mechanism is controlled or monitored by computer-based algorithms. Physical and software components are deeply interbedded in cyber-physical systems, and it can work at different spatial and temporal scales. In addition, it may exhibit multiple and divergent behavior patterns and interact with each other in ways that vary within the context. Process control is often referred to as embedded systems. Cyber Physical System is also like Internet of Things (IoT) sharing the same basic architecture. However, the Cyber-Physical System offers a higher combination and coordination between physical and computational elements (Lu, 2017).

Cyber-Physical Systems is one of the earliest systems used in Industry 4.0. Basically, it provides a link with sensors or other devices between real and virtual world. The system integrates with other technologies used in Industry 4.0; big data, sensor technology, cloud computing, augmented reality etc., so organizations benefit from the integration with other technologies for their business performance (Dengiz, 2017).

Especially, in logistics activities CPS is integrated with RFID technologies. Operations are carried out without using labor force when data is obtained via this integration. For example, CPS manage the shelves by replenishing products with automated robotics which has also augmented guidance through the warehouse hall. All movements are completed automatically through automated vehicles and robots. In the end, organizations benefit such advanced technologies and integrate it to their

business models, and they can minimize the costs, increase manufacturing levels, and way before checkout the risks and problems (Şekkeli and Bakan, 2018).

2.4.1.4. Big Data

Today, obtaining accurate and real-time data has become a strategic element of competitiveness. In fact, the concepts of data have become one of the significant elements along with the factors of productions. The combination of IoT and cloud computing usage allows different tools to be interconnected and large amounts of data to be collected. Big data consists of collecting data from systems and objects, such as sensor readings. The main importance of Big Data comes from the information it can generate.

Industry 4.0 provides enormous data for many different sectors and partners such as producers, suppliers, or customers via sensors used for storage of data. As the data needs high capacity of databases, the data needs to be kept in secure storages and managed properly. Within this context, the concept of Big Data emerges, and on the managerial point of view after analyzing Big Data would provide required information for decision on strategic operations (İyigün, 2019).

SC managers are increasingly dependent on data to predict expenditure, identify trends, improve process control, monitor inventory, optimize the production, and improve process efforts. Adapting data-driven strategies is considered as an important point of competitive differentiation. It also guarantees SC activities are efficient and transparent in terms of assets and staff. As a result of integrating the various types of data flow, more value-added services are provided, and more job possibilities are created in the sector. The relevance of leveraging Big Data is growing by the day as information technologies (WMS, VTS, GPS, RFID) utilized in the logistics sector produce massive amounts of data. For example, Big Data enables real-time route planning in logistical operations. As a result, firms in the logistics sector are increasing their investments in order to better use and analyze Big Data (Witkowski, 2017; Mishra et al., 2018).

2.4.1.5. Cloud Computing

Cloud technologies are now used to provide data storage solutions. The term "cloud" refers to an internet-connected network of services that is invisible to the user. The use of cloud computing eliminates the requirement for devices like hard disks. Data may be quickly accessed, saved, and analyzed thanks to the internet's technologies. Cloud computing platforms aid enterprises in achieving supply chain management synchronization. Businesses can minimize operational expenses and improve supply chain performance by applying accessibility and efficiency in supply chain when they use smart supply chain systems and cloud computing in their operations (Akben and Avşar, 2017; Iddris, 2018).

CHAPTER THREE
METHODOLOGICAL FRAMEWORK

In this chapter, it is aimed to be analyzed the information from the various company executives' responds on the information technologies that they use in their logistics or supply chain process. The obtained data were analyzed by using AHP method. Moreover, throughout the interviews, it was implemented purposeful sampling by asking the respondents open ended questions for obtaining more information about the sector's future, business segments and the effects of Covid 19 outbreak on their business. This chapter covers research framework, research method, analysis results and findings.

3.1. RESEARCH FRAMEWORK

3.1.1. Significance and Aim of the Research

This research aims to measure the factors and the results that will affect the performance of each member in supply chain by using information technologies. Numerous studies shows that information technologies have direct impact on supply chain and logistics performances of companies. Therefore, finding those criteria will reveal the importance of information technologies during supply chain or logistics activities. Thus, a comprehensive literature review has been conducted, after that the main and sub-criteria of research were formed.

The research has been conducted before and during the Covid 19 outbreak period, within this context the research gives further thought on how the firms approach their information technologies for their supply chain performance and logistics activities before and after the Covid 19. Purposeful sampling method also helped to reveal some point of views on Covid 19 and how it has affected their supply chain and logistics performances. Early on, appointments were accepted by various companies in order to conduct preliminary survey. It was interviewed with two firms for preliminary survey. The results of these surveys showed that the questionnaire and the methodology seem consistent. Main criteria and sub-criteria of information

technologies on supply chain and logistics performance have revealed the most appropriate approaches for the companies.

Another objective of the research is to show whether information technologies and applications on supply chain and logistics became distant in terms of different sectors. For this reason, research was conducted in various sectors including agriculture, food, home appliance manufacturing, package manufacturing, metal manufacturing and mold, plastic production, component manufacturing and welding. By including different sectors, the dimensions of information technologies on supply chain and logistics for these various sectors gives us more extensive consequences on how they can use these information technologies for their further activities. As it is showed that for having competitive advantage no matter how firms must improve their information technologies involvement on their supply chain and logistics activities (Gunasekaran et al, 2017).

3.1.2. Problem Statement

The companies need to select the most suitable information technologies for their supply chain or logistics processes, and these activities are not only suitable for the firm itself, but it is also significant for the companies' suppliers, partners, or shareholders. Besides, these information technologies cover various aspects within the organization such as adaptation of the system or the technology, investment for the technology, and selecting correct technology supplier and collaborating with the provider of the technology. Within the globalization, it is obvious that leading edge technologies affect all the process of business activities.

Particularly, supply chain management and the integration of all the parties in the supply chain make the information technologies more significant. The reasons behind that supply chain and logistics processes cover many different and complex activities. Besides, the adaptation process for the rapid changes in the business and the ability to respond the customer requests require companies to forecast those changes in advance and accommodate themselves in time.

In this rapidly changing business environment, logistics companies and supply chain members need the most suitable technologies to get competitive advantage and

sustain that advantage for the future. The main theme of the study is “the effects of the information technologies on supply chain performance and logistics activities”.

3.2. RESEARCH METHOD

In this part, information will be given related with questionnaire design and data collection. The data analysis and measurements will be provided in detail.

3.2.1. Questionnaire Design

Questionnaire survey was formed with several parts. In the first part, main and sub-criteria were gathered from various studies. Although there are numerous national and international studies on supply chain performance and logistics information systems, in this study, it is aimed to explore the specific point of view of a supply chain member by measuring the performance. By using key words “logistics information systems/programs/technologies”, “supply chain systems/technologies”, and “depth interviews”, many studies were analyzed. All factors/criteria were obtained for the AHP method to specify the questionnaire for the enterprises. These factors/criteria revealed the sub-factors/criteria. By finding these factors, AHP form and selection phase for the enterprises were developed. The factors/criteria were obtained from those studies were also significant to find out the road map on how the writers applied them for the enterprises. It was helpful to conduct the study onto pilot study - the preliminary survey for the various sectors. For the other step of questionnaire design, the depth interview method was implemented as it is an important qualitative method for having detailed information on participant’s feelings, opinions, and experiences (Milena et al, 2008). Thus, it is considered to implement purposeful sampling by asking the respondent open ended questions for obtaining more information about the sector’s future or business segments.

As it was mentioned, before the interviews were conducted with the interviewed companies, criteria were obtained from various sources from the literature and a questionnaire was prepared for these criteria. After the main criteria of the study

were created, sub-criteria were created according to its own structure. The criteria obtained from the literature are given in Table 3.

Table 3: Criteria used in Information Technologies

Main and sub-criteria used in the selection of Information Technologies	**Academics**
Total Cost	(Wei et al., 2005; Cebeci, 2009; Lien and Chan, 2007; Tomasz, 2016)
Implementation Time	(Wei et al., 2005; Cebeci, 2009; Lien and Chan, 2007; Closs et al., 1997)
Functionality	(Wei et al., 2005; Cebeci, 2009; Lien and Chan, 2007; Closs et al., 1997; Tomasz, 2016)
User friendliness	(Cebeci, 2009; Shen et al., 2016; Closs et al., 1997; Wei et al., 2005; Lien and Chan, 2007)
Flexibility	(Cebeci, 2009; Lien and Chan, 2007; Wei et al., 2005; Closs et al., 1997; Batarlienė and Jarašūnienė, 2017; Shen et al., 2016)
Investment	(Cebeci, 2009; Wei et al., 2005; Shen et al., 2016)
Ability for upgrade in-house	(Cebeci, 2009; Wei et al., 2005; Tomasz, 2016; Shen et al., 2016)
Reliability	(Lien and Chan, 2007; Cebeci, 2009; Wei et al., 2005)
Vendor / Vendor reputation / Vendor technical capability	(Lien and Chan, 2007; Cebeci, 2009; Wei et al., 2005; Bayraktar and Mehmet, 2006)
Ability to integrate other systems and business processes	(Cebeci, 2009; Lien and Chan, 2007; Closs et al., 1997; Bayraktar and Mehmet, 2006; Shen et al., 2016)
System	(Cebeci, 2009; Wei et al., 2005; Lien and Chan, 2007)
After sales services	(Cebeci, 2009; Lien and Chan, 2007; Wei et al., 2005; Bayraktar and Mehmet, 2006)
Infrastructure costs	(Wei et al., 2005; Bayraktar and Mehmet, 2006)
Task management	(Tomasz, 2016)
Portability	(Lien and Chan, 2007)
Partners management	(Tomasz, 2016)
Documenting and reporting	(Tomasz, 2016)
Information sharing	(Closs et al., 1997)

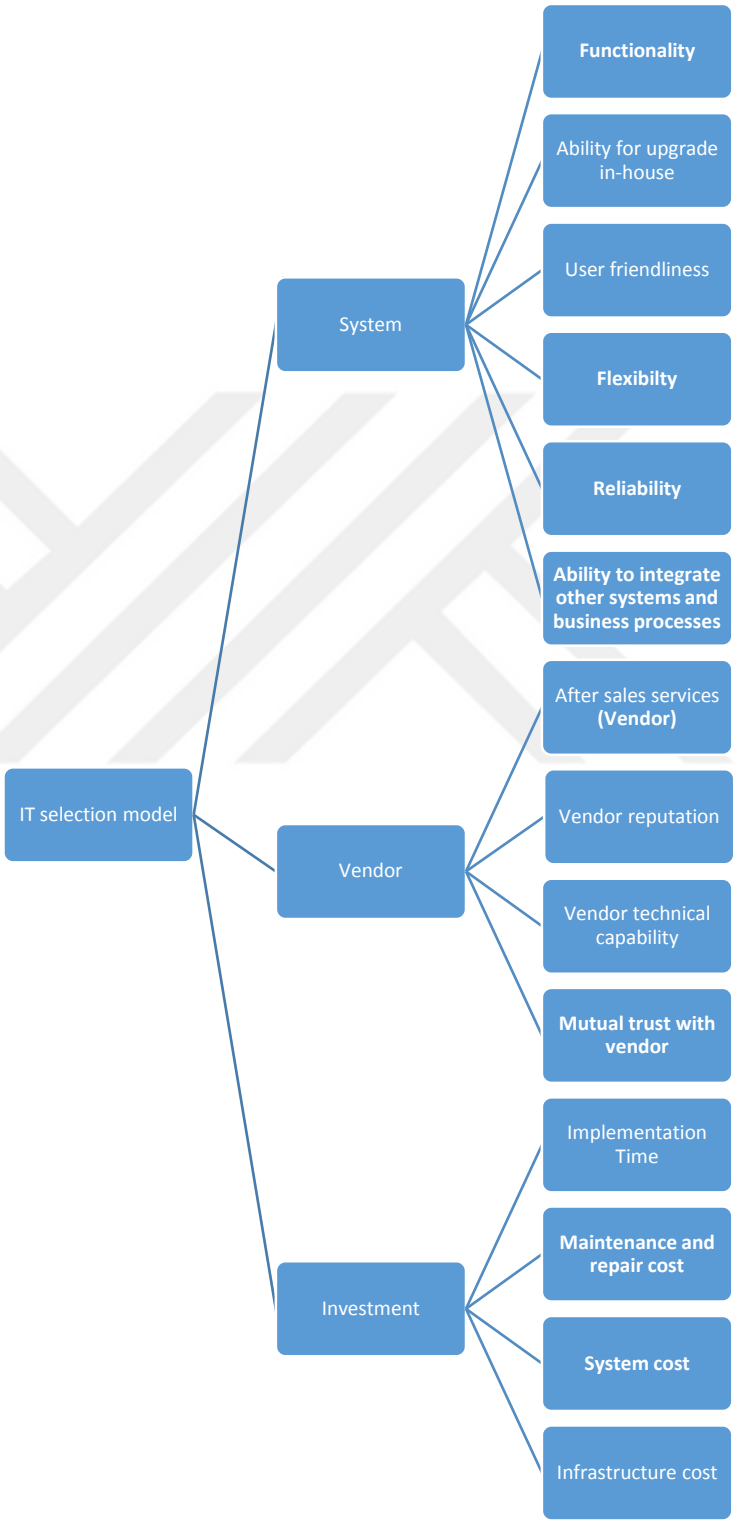
Source: Created by the Author.

As it can be seen in Table 3, we can see that new factors are included in the studies within the scope of time-based information technologies and the development of these technologies while it is used in the same way on different dates. Hence, choosing the right criteria will help organizations to measure the impact of information technologies on their supply chains. Therefore, even though organizations operate in different sectors, they will be able to create the processes of determining their specific needs more easily with the criteria they will use in the selection process of information technologies.

With the list of criteria obtained in Table 3, early on face-to-face interviews were conducted with the foreign trade executive in the mold manufacturing sector and the logistics unit manager engaged in manufacturing package. In parallel with these interviews, our selection model was finalized. In the direction of the findings, we obtained from our model, our AHP question format was prepared. In the next process, a pilot test was conducted by interviewing two companies. Some criteria have been removed regarding the responds received as a result of the pilot test. In addition, a criterion (mutual trust with vendor) that is not included in Table 3 was also added to the questionnaire. The final version of our model is given in Figure 13.

In accordance with the model, there are totally three parts in the questionnaire form. First two parts contain the matrices for analysing the main criteria and sub-criteria relationships. In the last part, some open-ended questions are provided in terms of participant's job title, size of the business, number of the employees, questions related with information technologies withing the organization and integration of IT systems onto their logistics activities and supply chain processes, and at last, general views about the future of implications for their sector. In addition, the interviews were conducted during the Covid-19 pandemic period, so it was also asked some extra questions to evaluate their business cycles and business flows before and after Covid-19 pandemic period regarding with their IT systems. "Are there any improvement on their systems or not?", "How does the current IT system of your business react the developments during Covid-19 period, considering your partners, suppliers, distributors, or customers?" These questions were also asked at the end of the interviews. Questionnaire form is provided in Appendix 1.

Figure 13: The Hierarchical Structure of the IT Selection Model



Source: Created by the Author.

3.2.2. Sample and Data Collection

The implementation sample consists of respondents from the IT, logistics, foreign trade, transportation, and supply chain departments seniors. The companies' field of operations are; component manufacturing, agriculture, package manufacturing, plastic production, home appliance manufacturing, food, metal manufacturing and mold, and welding. The problem in here to establish the sample size in multi criteria decision making based approaches in order to achieve high accuracy rates by offering error minimization and valid comparison matrices were disputed. Although there is no set rule for establishing the number of decision-makers from whom data should be obtained, it is recommended that the number of respondents should be between 5 and 10 (Özbekler and Akgül, 2020). As a result, one decision-maker from each sector and a total of 18 respondents were chosen for this study. Furthermore, a purposeful sampling technique was selected for this study. In implementation structure of research, a purposeful sampling is widely used to identify and select information-rich subjects related to the topic (Benoot et al., 2016). In the following part, there will be given the information about sectors and organizations involved in the research.

Table 4: Information of Interviewed Companies

	Scale of Enterprise	**Companie's field of operation**	**IT department**	**Integration of IT with logistics activities and SCM**	**Respondent's Position**
Firm A	Small and medium enterprise (SME)	Producing flexible packaging and in-mold labelling	Yes	Yes	Logistics expert
Firm B	Large scaled	Producing components for home appliance	Yes – two different IT departments	Yes	Supply chain coordinator
Firm C	Large scaled	Plastic production	Yes	Yes	Logistics expert

Firm D	Large scaled	Manufacturing agricultural machinery and agricultural products	Yes	Yes	Executive board member and IT department
Firm E	SME	manufacturing plastics for lawn tools	Yes	Yes	Export – import manager
Firm F	Large scaled	manufacturing induction heating systems and welding	Yes	Yes / integrated with WMS	Export – import manager
Firm G	SME	producing plastic and serigraphy	Yes	Yes	IT executive
Firm H	SME	Metal manufacturing	Yes	Yes	IT manager
Firm I	SME	Food industry	Yes - Outsourcing	Yes	Logistics manager
Firm J	SME	Manufacturing 3D pens and printers	Yes	Yes	IT manager
Firm K	Large scaled	Manufacturing durable goods	Yes / integrated with different groups and various geographical locations	Yes	R&D manager
Firm L	Large scaled	Manufacturing boilers and other heating products	Yes	Yes	Logistics manager
Firm M	Large scaled	Manufacturing high-performance technical textiles	Yes	Yes	Logistics manager
Firm N Online interview	SME	Producing electrodes and welding wires	Yes	Yes	Foreign trade executive
Firm O Online interview	SME	Producing plastic and mold injection	Yes - Outsourcing	Yes	Logistics manager

Firm P Online interview	SME	Manufacturing plastics for home appliances	Yes	Yes	IT executive
Firm R Online interview	SME	Manufacturing plastic wireless electronic training set	Yes	Yes	Logistics manager
Firm S Online interview	SME	Manufacturing metal and mold for heating products	Yes	Yes	Transportation department executive

Source: Created by the Author.

In Table 4, information given about the interviewed companies. All the interviewed companies are in Manisa Industrial Park. There are totally 18 (eighteen) interviews, and 8 (eight) of them were conducted during Covid 19 period. Before Covid 19, the interviews were conducted face to face with the number of 10 (ten) companies. During the Covid 19 period appointments were taken for the interviews, yet because of the lockdown period, companies cancelled or postponed their appointments, and when communicated with the companies again later, five of them accepted to carry out the interviews online, and three interviews were carried out face to face within the compliance of the measures taken and the rules applied during Covid 19 period.

Online interviews were all carried out via zoom software program which is a communication program with video and audio feed. Both online and face to face interviews took 20 – 25 minutes. Moreover, there were delays for the interview dates because apart from Covid 19 pandemic conditions, there were also difficulties regarding budget, time, and unavailableness of participants.

3.2.3. Data Analysis and Measurement

In the context of data analysis and measurement Analytical Hierarchy Process (AHP) method was used. AHP is a decision-making method used in solving multi-

criteria decision-making problems. With AHP method, it is possible to analyze both quantitative and qualitative criteria by processing them through a hierarchical structure. Analyzing the organizations' IT selection on SCM performance can also be considered as a multi-criteria decision-making problem, so quantitative and qualitative criteria can be analyzed together due to its nature. For this reason, the AHP method is also used as a performance evaluation tool (Islam and bin Mohd Rasad, 2006; Ayağ and Özdemir, 2006).

AHP has a wide range of application area since it is a multivariate decision-making technique. Particularly, it is used for weighted ordering of options, especially in problems with a finite number of options. AHP is widely used method and it can be used in many areas such as marketing, purchasing, finance, education, public policies, economy, health, customer relations, strategic planning, production, and quality management to solve problems in the structure of decision making among all kinds of variables.

With the AHP method, the problem is determined first and the criteria, sub-criteria and alternatives belonging to the problem are revealed by creating a hierarchical structure. By making pairwise comparisons, comparison matrix is obtained, and the importance level of each criterion is determined from the data. As a result of the method application, all criteria are evaluated and the best option or the best ranking can be found together with the importance levels (Al-Harbi, 2001). The theoretical development of the AHP method took place between 1974 and 1978. Saaty discussed the method in the book "The Analytic Hierarchy Process" in 1980 and explained it in detail (Saaty, 2008).

Reasons for using AHP:

- The method is found natural, and it is not hesitated to use the method.
- No advanced technical knowledge is required to use it.
- It may contain data that can be called an eyeball estimate based on people's feelings, emotions, and thoughts.
- It can be considered the subjective evaluation among the measured data.
- AHP enables pairwise comparisons to be made regarding evaluated criteria, instead of considering and selecting a specific score.

- With a simple and effective procedure, a result can be achieved even with different experiences and opinions.
- With AHP it is possible to get the judgments of decision makers into consideration as well as their thoughts.
- It can be used both measurable and non-measurable data.
- The AHP method can be used directly in the areas of resource allocation, benefit/cost analysis, analyzing convergence, and system design optimization (Saaty, 2008).

AHP is a decision making and forecasting method. AHP method is applied when decision hierarchy can be defined. A predefined comparison scale is used on the decision hierarchy. As a result of the method, as the percentage distributions of the decision points based on the criteria affecting the decision are obtained, and their ranking according to their importance values is formed (Badi and Abdulshahed, 2019; Albayrak and Erensal; 2004).

In the AHP method, the following steps are followed, respectively:

- The problem is determined, the objective that will be at the top of the hierarchy is determined.
- By creating a hierarchy, criteria, sub-criteria, and alternatives are determined
- Pairwise comparison matrix is formed.
- The weight vector is found by using the pairwise comparison matrix.
- By calculating the consistency ratio, the decision is made in case of consistency.
- If it isn't consistent, the pairwise comparisons are reviewed and the analysis is repeated (Gaudenzi and Borghesi, 2006).

In order to have accurate results by using the AHP method, some important points should be known to implement. Some of the significant points are:

- The problem and the objective should be defined accurately and completely for implementing.
- The most appropriate options and criteria for the purpose should be determined.
- There should not be too many differences between the options.
- The criteria must be independent of each other.
- If criterion A is m times more important than criterion B, criterion B is considered 1/m times more important than criterion A.

- The options must be independent of each other in order to evaluate the criteria correctly,
- While forming the groups in the hierarchical structure, it should be considered that the elements of the group will be considered independent from each other, and the elements between the groups may affect each other.
- The large number of criteria may reduce consistency (Tüysüz and Şimşek, 2017).

AHP is carried out on three basic principles: establishing hierarchy, synthesis and analysis of the priorities and measuring the logical and numerical consistency (Görener, 2012).

The method begins with the preparation of a matrix consisting of two stages, adhering to expert opinions. Pairwise comparison matrix is given in equation 1.

$$\begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix} \quad (1)$$

In here $i, j = 1,2,3, \dots, n$ including $i, j: criteria\ or\ alternatives$ and $a_{ij}: the\ relative\ importance\ of\ the\ criterion\ or\ alternative\ in\ the\ column$ is $i = j \Longrightarrow a_{ij} = 1;\ a_{ij} = x \Longrightarrow a_{ji} = \frac{1}{x}; a_{ij} \neq 0.$

Each cell in the matrix can only be compared to its column total. In equation 2 the calculation is presented.

$$\frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \quad (2)$$

Then the average of each value in the row is calculated. The importance levels of the criterion and alternative are possible with the values obtained in the relevant row. w_i, i. the significance level of criteria and alternative is provided with analyzing in equation 3.

$$w_i = \frac{\sum_{j=1}^{n} \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}}{n} \quad (3)$$

Consistency ratios are calculated to measure the reliability levels of the obtained values. The consistency ratio is calculated by multiplying the evaluations taken from expert opinions with the previously conducted pairwise comparison matrix and the matrix giving the importance levels.

This formulation is given in equation 4.

$$\begin{bmatrix}\lambda_1\\ \lambda_2\\ \dots\\ \lambda_n\end{bmatrix}=\begin{bmatrix}a_{11} & a_{12} & \dots & a_{1n}\\ a_{21} & a_{22} & \dots & a_{2n}\\ \dots & \dots & \dots & \dots\\ a_{n1} & a_{n2} & \dots & a_{nn}\end{bmatrix}\begin{bmatrix}w_1\\ w_2\\ \dots\\ w_n\end{bmatrix} \quad (4)$$

The average of the values is obtained in equation 4. The procedure performed is given in equation 5.

$$\lambda_{max}=\frac{\sum_{i=1}^{n}\lambda_i}{n} \quad (5)$$

After the calculations, the consistency index is calculated with the formulation in equation 6.

$$CI=\frac{\lambda_{max}-n}{n-1} \quad (6)$$

Finally, the random index value and the consistency index value are estimated, and the consistency ratio is found. The random index value, which is a table value, depends on the matrix size. Calculation of its consistency ratio is given by following equation 7.

$$CR=\frac{CI}{RI} \quad (7)$$

If the CR value is less than 0.1, results are considered consistent. In here, CI consistency index and RI random index values are defined (Özdağoğlu and Özdağoğlu, 2007; Keleş et al., 2019).

It is important to measure how sensitive the results of the AHP application are to the changes to be made on the parameters. Differences on pairwise comparison procedures may vary according to person and time. By evaluating the differences that may occur in the mindset and assessment, the sensitivity of the results of the AHP method is analyzed. In the light of these measurement results, necessary formations can be analyzed on the structure.

3.3. MAIN STUDY FINDINGS

In this study, an Excel file was created using the equations and formulations from the previous part, with 3 main criterion and 14 sub-criteria. The questionnaire is then administered with the help of 18 experts from various fields. On a questionnaire form, participants presented their own ideas and knowledge, and the scoring and

assessments of the participants were afterwards placed into a prepared Excel to calculate the AHP equations.

The empirical findings of the study will be given in terms of the findings before Covid 19 period, the findings after Covid 19 period and all empirical findings.

3.3.1. The Findings Before Covid 19 Period

Before Covid 19 period, using the questionnaire form prepared within the model, the interviews were conducted with business officials. The answers obtained from the interviews generated the initial pairwise comparison matrices. Afterwards, the geometric averages of the responds given by the participants were taken and the results were combined. Pairwise comparison of the main criteria is given in Table 5. The information was obtained from the respondent by geometric average.

Table 5: Pairwise Comparison Matrix for Main Criteria (Before Covid 19 Period)

	System	**Vendor**	**Investment**
System	1,0000	4,7287	3,9360
Vendor	0,2115	1,0000	0,4401
Investment	0,2541	2,2724	1,0000

Source: Created by the Author.

In Table 6, the ratio of each cell to the total of its own column is given for main criteria.

Table 6: Dividing each cell by its own column total (Main criteria) (Before Covid 19 Period)

	System	**Vendor**	**Investment**
System	0,6823	0,5910	0,7321
Vendor	0,1443	0,1250	0,0819
Investment	0,1734	0,2840	0,1860

Source: Created by the Author.

In Table 7, the average of the values in each row in Table 6 is taken and the importance level of each main criterion was obtained.

Table 7: The Importance Levels (Main Criteria) (Before Covid 19 Period)

	The Importance Levels
System	0,6685
Vendor	0,1170
Investment	0,2145

Source: Created by the Author.

Consistency ratio calculations are made in order to check the consistency of the importance levels obtained in Table 7. The first step for the consistency ratio calculation is to multiply the initial data comparison matrix by the importance levels matrix. In the second step of the consistency ratio calculation, the values obtained in step 1 are calculated in accordance with the corresponding importance levels. After obtaining the results of Step 2, the consistency index (CI) and consistency ratio (CR) are calculated. Since the obtained consistency ratio was less than 0.1, it is determined that the obtained results are consistent. The values obtained during the consistency ratio calculation process are given in Table 8.

Table 8: The Consistency Ratio Matrix (Main Criteria) (Before Covid 19 Period)

Step 1 Results	**Step 2 Results**		
2,0661	3,0907	**CI =**	0,0228
0,3528	3,0141	**RI =**	0,5800
0,6503	3,0322	**CR =**	0,0394
$\boldsymbol{\lambda_{max}} =$	3,0456		

Source: Created by the Author.

After the completion of these processes regarding the main criteria, the same process is repeated for the sub-criteria related to each main criterion. The pairwise comparison matrix for the sub-criteria related to the "System" main criterion is presented in Table 9.

Table 9: The Pairwise Comparison Matrix for Sub-Criteria Related to The System Main Criterion (Before Covid 19 Period)

System	Functionality	User friendliness	Flexibili ty	Reliability	Ability to integrate other systems and business processes	Ability for upgrade in-house
Functionality	1,0000	3,1623	2,9428	2,2795	2,6321	2,6321
User friendliness	0,3162	1,0000	0,2812	0,2541	0,5623	0,2659
Flexibility	0,3398	3,5566	1,0000	0,4204	0,6580	1,1247
Reliability	0,4387	3,9360	2,3784	1,0000	3,9360	3,1623
Ability to integrate other systems and business processes	0,3799	1,7783	1,5197	0,2541	1,0000	1,0746
Ability for upgrade in-house	0,3799	3,7606	0,8891	0,3162	0,9306	1,0000

Source: Created by the Author.

In Table 10, the ratio of each cell to its column total is obtained.

Table 10: Dividing Each Cell by The Total of The Column for Sub-Criteria of System Main Criteria (Before Covid 19 Period)

System	Functionality	User friendliness	Flexibility	Reliability	Ability to integrate other systems and business processes	Ability for upgrade in-house
Functionality	0,3503	0,1839	0,3266	0,5038	0,2708	0,2843
User friendliness	0,1108	0,0582	0,0312	0,0562	0,0579	0,0287
Flexibility	0,1190	0,2069	0,1110	0,0929	0,0677	0,1215
Reliability	0,1537	0,2289	0,2639	0,2210	0,4050	0,3415
Ability to integrate other systems and business processes	0,1331	0,1034	0,1686	0,0562	0,1029	0,1160
Ability for upgrade in-house	0,1331	0,2187	0,0987	0,0699	0,0958	0,1080

Source: Created by the Author.

Table 11: The Importance Levels of The Sub-Criteria of The System Main Criterion (Before Covid 19 Period)

	Importance Levels
Functionality	0,3200
User friendliness	0,0571
Flexibility	0,1198
Reliability	0,2690
Ability to integrate other systems and business processes	0,1134
Ability for upgrade in-house	0,1207

Source: Created by the Author.

In Table 11, by calculating the consistency ratios, the importance levels are revealed. As the first step, the initial data comparison matrix and the importance matrix are multiplied. For the calculation of the consistency ratio in the second step, it is compared with the values obtained in the first step and the ratio is given according to

the importance levels. After obtaining the results of step 2, both the consistency index (CI) and the consistency ratio (CR) are analyzed. Consistency ratio is less than 0.1, so the results are found to be consistent. The values obtained during the consistency ratio calculation process are given in Table 12.

Table 12: The Consistency Ratio of The Sub-Criteria of The System Main Criterion (Before Covid 19 Period)

Step 1 Results	**Step 2 Results**		
2,0826	6,5090	**CI =**	0,0704
0,3562	6,2334	**RI =**	1,2400
0,7552	6,3027	**CR =**	0,0567
1,7472	6,4949		
0,7167	6,3213		
0,7543	6,2498		
$\boldsymbol{\lambda_{max}} =$	6,3518		

Source: Created by the Author.

A long the same way, with the completion of the processes within the main criteria, a sub-criteria analysis based on another main criterion is made. The pairwise comparison matrix for the sub-criteria related to the “Vendor” main criterion is presented in Table 13.

Table 13: The Pairwise Comparison Matrix for The Sub-Criteria Based on Vendor Main Criterion (Before Covid 19 Period)

Vendor	After sales services (Vendor)	Vendor reputation	Vendor technical capability	Mutual trust with vendor
After sales services (Vendor)	1,0000	3,1623	1,7783	0,9840
Vendor reputation	0,3162	1,0000	0,2659	0,4653
Vendor technical capability	0,5623	3,7606	1,0000	1,9680
Mutual trust with vendor	1,0163	2,1491	0,5081	1,0000

Source: Created by the Author.

The ratio of each cell to its column total is found in Table 14.

Table 14: Dividing Each Cell by The Total of The Column for Sub-Criteria of Vendor Main Criteria (Before Covid 19 Period)

Vendor	After sales services (Vendor)	Vendor reputation	Vendor technical capability	Mutual trust with vendor
After sales services (Vendor)	0,3454	0,3140	0,5006	0,2228
Vendor reputation	0,1092	0,0993	0,0749	0,1053
Vendor technical capability	0,1943	0,3734	0,2815	0,4455
Mutual trust with vendor	0,3511	0,2134	0,1430	0,2264

Source: Created by the Author.

Table 15: The Importance Levels of The Sub-Criteria of The Vendor Main Criterion (Before Covid 19 Period)

	Importance Levels
After sales services (Vendor)	0,3457
Vendor reputation	0,0972
Vendor technical capability	0,3237
Mutual trust with vendor	0,2335

Source: Created by the Author.

The importance levels of the sub-criteria of the supplier main criterion are found in Table 15 by calculating the consistency ratio. The first step is performed by multiplying the initial data comparison matrix with the importance matrix. The ratio is compared with the values obtained in the first step and the second step consistency ratio calculation is reached. Consistency index (CI) and consistency ratio (CR) are found within the results of step 2. The consistency ratio reached is less than 0.1, the result is consistent. In Table 16, the values are provided that is obtained from the consistency ratio calculation process

Table 16: The Consistency Ratio of The Sub-Criteria of The Vendor Main Criterion (Before Covid 19 Period)

Step 1 Results	**Step 2 Results**		
1,4583	4,2185	**CI =**	0,0500
0,4012	4,1284	**RI =**	0,9000
1,3430	4,1493	**CR =**	0,0556
0,9581	4,1038		
$\boldsymbol{\lambda_{max}} =$	4,1500		

Source: Created by the Author.

Table 17: The Pairwise Comparison Matrix for The Sub-Criteria Based on Investment Main Criterion (Before Covid 19 Period)

Investment	**Implementation Time**	**Maintenance and repair cost**	**System cost**	**Infrastructure cost**
Implementation Time	1,0000	4,1618	1,8612	4,1618
Maintenance and repair cost	0,2403	1,0000	0,3976	0,4204
System cost	0,5373	2,5149	1,0000	1,7783
Infrastructure cost	0,2403	2,3784	0,5623	1,0000

Source: Created by the Author.

The ratio of each cell to its column total is found in Table 18.

Table 18: Dividing Each Cell by The Total of The Column for Sub-Criteria of Investment Main Criteria (Before Covid 19 Period)

Investment	**Implementation Time**	**Maintenance and repair cost**	**System cost**	**Infrastructure cost**
Implementation Time	0,4956	0,4139	0,4871	0,5654
Maintenance and repair cost	0,1191	0,0995	0,1041	0,0571
System cost	0,2663	0,2501	0,2617	0,2416
Infrastructure cost	0,1191	0,2365	0,1472	0,1359

Source: Created by the Author.

Table 19: The Importance Levels of The Sub-Criteria of The Investment Main Criterion (Before Covid 19 Period)

	Importance Levels
Implementation Time	0,4905
Maintenance and repair cost	0,0949
System cost	0,2549
Infrastructure cost	0,1597

Source: Created by the Author.

In Table 19, the importance levels of the sub-criteria belonging to the investment main criterion is analyzed in terms of calculating the consistency ratio. The steps taken in the previous formulas are repeated and with the results obtained, the consistency ratio (CR) and consistency index (CI) data are reached. Consistency ratio obtained is less than 0.1, so the result is consistent. In Table 20, the data obtained during the consistency ratio analysis is presented.

Table 20: The Consistency Ratio of The Sub-Criteria of The Investment Main Criterion (Before Covid 19 Period)

Step 1 Results	**Step 2 Results**		
2,0245	4,1275	**CI =**	0,0232
0,3813	4,0165	**RI =**	0,9000
1,0411	4,0841	**CR =**	0,0258
0,6466	4,0501		
λ_{max} =	4,0695		

Source: Created by the Author.

In the last part, all the matrix results obtained were summed, and it is provided both local importance levels global importance levels. The results are given in Table 21.

Table 21: Converting the Matrix Results by Summing Local Importance Levels and Global Importance Levels Before Covid 19 Period

		Local Importance Levels	**Global Importance Levels**
mc1	**System**	0,6685	
mc2	**Vendor**	0,1170	
mc3	**Investment**	0,2145	
sc11	**Functionality**	0,3200	0,2139
sc12	**User friendliness**	0,0571	0,0382
sc13	**Flexibility**	0,1198	0,0801
sc14	**Reliability**	0,2690	0,1798
sc15	**Ability to integrate other systems and business processes**	0,1134	0,0758
sc16	**Ability for upgrade in-house**	0,1207	0,0807
sc21	**After sales services (Vendor)**	0,3457	0,0405
sc22	**Vendor reputation**	0,0972	0,0114
sc23	**Vendor technical capability**	0,3237	0,0379
sc24	**Mutual trust with vendor**	0,2335	0,0273
sc31	**Implementation time**	0,4905	0,1052
sc32	**Maintenance and repair cost**	0,0949	0,0204
sc33	**System cost**	0,2549	0,0547
sc34	**Infrastructure cost**	0,1597	0,0342

Source: Created by the Author.

Before Covid 19 period, the empirical findings show that measuring IT in order to comprehend SCM performance; among the main criterion “System” has the highest local importance level with 66.85%, and respectively “Investment” with 21.45% local importance level, and then “Vendor” is listed with 11.70% local importance level.

In accordance with the local importance level, Among the sub-criteria of the “System” main criterion, “Functionality” has the highest value with 32%, while “User Friendliness” has the lowest value with 5.71%. In addition, for the other sub-criteria

of “System” main criteria; “Reliability” has 26.90%, “Flexibility” has 11.98%, “Ability to integrate other systems and business processes” has 11.34% and “Ability for upgrade in-house” has 12.07% local importance levels. This similarity is closer to each other regarding with the global importance levels of the parameters. When it is considered the sub-criteria of “System” main criteria in terms of global importance level, “Reliability” has 17,98% and “Functionality” has 21,39% while with the value of 3,82% “User Friendliness” and “Ability to integrate other systems and business processes” with 7,58% numeric have the lowest global importance level.

When the “Vendor” main criteria is analyzed, its “After sales services (Vendor)” sub-criteria has the highest rate with 34,57%, “Vendor reputation” sub-criteria has the lowest value with 9,72% regarding with local importance level. Moreover, when the local importance level of other sub-criteria of “Vendor” are analyzed, there are with the value 32,37% “Vendor technical capability”, and with 23,35% “Mutual trust with vendor”. When the global importance level of sub-criteria of “Vendor” main criteria is analyzed, “After sales services (Vendor)” sub-criteria is 4,05%, and the sub-criteria “Vendor technical capability” is 3,79%, these two sub-criteria have the highest rates. The sub-criteria “Mutual trust with vendor” (2,73%) and “Vendor reputation” (1,14%) have the lowest values on global importance level.

Finally, when the sub-criteria of “Investment” main criteria is considered, “Implementation time” (49,05%) has the highest value for local importance level, yet “Maintenance and repair cost” (9,49%) sub-criteria has the lowest local importance level. Other sub-criteria “System cost” has 25,49% and “Infrastructure cost” has 15,97% local importance level. On the other hand, for the global importance level of “Investment” main criteria, its sub-criteria “Implementation time” (10,52%) has the highest one, and “Maintenance and repair cost” sub-criteria has the lowest value among other sub-criteria.

When all sub-criteria are taken consideration, “Functionality” sub-criteria under “System” main criteria has the highest global importance value with 21%, and “Vendor reputation” sub-criteria belonging to “Vendor” main criteria has the lowest rate with 1,14% among all other sub-criteria.

3.3.2. The Findings After Covid 19 Period

Within the Covid 19 period, the interviews are conducted under the circumstances of Covid 19 protocols. During this period 8 (eight) interviews were carried out, and 5 (five) of them were online interviews. The procedures of having the results are analyzed with the same way. First initial pairwise comparison matrices formed from the responds of decision-makers. Then, geometric averages of the interviews are analyzed and summed with the results at the end. In Table 22, firstly pairwise comparison belongs to main criteria is given in terms of after Covid 19 period.

Table 22: Pairwise Comparison Matrix for Main Criteria (After Covid 19 Period)

	System	**Vendor**	**Investment**
System	1,0000	3,8501	1,1838
Vendor	0,2597	1,0000	0,4977
Investment	0,8448	2,0091	1,0000

Source: Created by the Author.

The ratio of each cell to the total of its own column is given for main criteria in Table 23.

Table 23: Dividing each cell by its own column total (Main criteria) (After Covid 19 Period)

	System	**Vendor**	**Investment**
System	0,5189	0,5698	0,4962
Vendor	0,1329	0,1459	0,1709
Investment	0,3482	0,2843	0,3329

Source: Created by the Author.

In Table 24, the values average for each row in Table 23 is collected and the importance level of each main criteria is calculated.

Table 24: The Importance Levels (Main Criteria) (After Covid 19 Period)

	The Importance Levels
System	0,5283
Vendor	0,1499
Investment	0,3218

Source: Created by the Author.

Calculations of consistency ratios are performed to ensure that the importance levels obtained in Table 24 which is consistent. The initial data comparison matrix is multiplied by the importance levels matrix to calculate the consistency ratio. The values acquired in step 1 are calculated in line with the respective importance levels in the second phase of the consistency ratio computation. The consistency index (CI) and consistency ratio (CR) are calculated after the findings of Step 2 are obtained. Because the resulting consistency ratio is less than 0.1, and the acquired data is found to be consistent. Table 25 shows the values acquired during the consistency ratio computation method.

Table 25: The Consistency Ratio Matrix (Main Criteria) (After Covid 19 Period)

Step 1 Results	**Step 2 Results**		
1,5933	3,0158	**CI =**	0,0049
0,4503	3,0045	**RI =**	0,5800
0,9684	3,0091	**CR =**	0,0084
$\boldsymbol{\lambda_{max}} =$	3,0098		

Source: Created by the Author.

After these processes for the main criteria are completed, the same process is done for the sub-criteria for each main criterion. Table 26 shows the pairwise comparison matrix for the sub-criteria related to the "System" main criteria.

Table 26: The Pairwise Comparison Matrix for Sub-Criteria Related to The System Main Criterion (After Covid 19 Period)

System	Function ality	Us er friendliness	Flexibility	Reliability	Ability to integrate other systems and business processes	Ability for upgrade in-house
Functionality	1,0000	3,0401	1,6719	0,9253	1,7436	2,5715
User friendliness	0,3289	1,0000	0,7706	0,3222	0,6654	0,6256
Flexibility	0,5981	1,2977	1,0000	0,5827	0,7312	1,1418
Reliability	1,0807	3,1032	1,7160	1,0000	2,2146	2,1415
Ability to integrate other systems and business processes	0,5735	1,5029	1,3675	0,4515	1,0000	1,9106
Ability for upgrade in-house	0,3889	1,5985	0,8758	0,4670	0,5234	1,0000

Source: Created by the Author.

The ratio of each cell to its column total is obtained in Table 27.

Table 27: Dividing Each Cell by The Total of The Column for Sub-Criteria of System Main Criteria (After Covid 19 Period)

System	Functionality	User friendly ness	Flexibility	Reliability	Ability to integrate other systems and business processes	Ability for upgrade in-house
Functionality	0,2519	0,2634	0,2259	0,2468	0,2535	0,2738
User friendliness	0,0829	0,0866	0,1041	0,0860	0,0967	0,0666
Flexibility	0,1507	0,1124	0,1351	0,1554	0,1063	0,1216
Reliability	0,2722	0,2689	0,2318	0,2667	0,3220	0,2280
Ability to integrate other systems and business processes	0,1445	0,1302	0,1848	0,1204	0,1454	0,2035
Ability for upgrade in-house	0,0979	0,1385	0,1183	0,1246	0,0761	0,1065

Source: Created by the Author.

The important levels are presented in Table 28 by computing the consistency ratios. The initial data comparison matrix and the importance level matrix are multiplied as the first step. In the second phase, the consistency ratio is calculated by comparing the values produced in the first step to the values obtained in the second step, and the ratio is presented according to the important levels. The consistency index (CI) and the consistency ratio (CR) are calculated after the outcomes of step 2. The consistency ratio is smaller than 0.1, indicating that the results are consistent.

Table 28: The Importance Levels of The Sub-Criteria of The System Main Criterion (After Covid 19 Period)

	Importance Levels
Functionality	0,2525
User friendliness	0,0872
Flexibility	0,1303
Reliability	0,2649
Ability to integrate other systems and business processes	0,1548
Ability for upgrade in-house	0,1103

Source: Created by the Author.

The numeric obtained in the consistency ratio analysis is given in Table 29.

Table 29: The Consistency Ratio of The Sub-Criteria of The System Main Criterion (After Covid 19 Period)

Step 1 Results	**Step 2 Results**		
1,5340	6,0741	**CI =**	0,0124
0,5280	6,0582	**RI =**	1,2400
0,7879	6,0493	**CR =**	0,0100
1,6109	6,0801		
0,9391	6,0674		
0,6666	6,0430		
λ_{max} =	6,0620		

Source: Created by the Author.

Similarly, once the processes within the main criteria have been completed, a sub-criteria analysis based on another main criterion is performed. Table 30 shows the pairwise comparison matrix for the sub-criteria related to the "Vendor" main criteria.

Table 30: The Pairwise Comparison Matrix for The Sub-Criteria Based on Vendor Main Criterion (After Covid 19 Period)

Vendor	**After sales services (Vendor)**	**Vendor reputation**	**Vendor technical capability**	**Mutual trust with vendor**
After sales services (Vendor)	1,0000	3,1386	1,5792	1,3004
Vendor reputation	0,3186	1,0000	0,3195	0,5089
Vendor technical capability	0,6332	3,1294	1,0000	1,2750
Mutual trust with vendor	0,7690	1,9650	0,7843	1,0000

Source: Created by the Author.

In Table 31, the ratio of each cell to its column total is presented.

Table 31: Dividing Each Cell by The Total of The Column for Sub-Criteria of Vendor Main Criteria (After Covid 19 Period)

Vendor	**After sales services (Vendor)**	**Vendor reputation**	**Vendor technical capability**	**Mutual trust with vendor**
After sales services (Vendor)	0,3675	0,3399	0,4288	0,3184
Vendor reputation	0,1171	0,1083	0,0868	0,1246
Vendor technical capability	0,2327	0,3389	0,2715	0,3122
Mutual trust with vendor	0,2826	0,2128	0,2130	0,2448

Source: Created by the Author.

Table 32: The Importance Levels of The Sub-Criteria of The Vendor Main Criterion (After Covid 19 Period)

	Importance Levels
After sales services (Vendor)	0,3637
Vendor reputation	0,1092
Vendor technical capability	0,2888
Mutual trust with vendor	0,2383

Source: Created by the Author.

Table 32 shows the importance levels of the sub-criteria of the "Vendor" main criteria calculated using the consistency ratio. The initial data comparison matrix is multiplied by the importance matrix in the first phase. The consistency ratio is calculated in the second step after the ratio is compared to the values acquired in the first stage. The consistency index (CI) and consistency ratio (CR) can be discovered in the step 2 results. The consistency ratio achieved is less than 0.1, indicating that the outcome is reliable. The values received from the consistency ratio calculation method are listed in Table 33.

Table 33: The Consistency Ratio of The Sub-Criteria of The Vendor Main Criterion (After Covid 19 Period)

Step 1 Results	**Step 2 Results**		
1,4724	4,0489	**CI =**	0,0102
0,4386	4,0171	**RI =**	0,9000
1,1647	4,0323	**CR =**	0,0114
0,9591	4,0244		
$\boldsymbol{\lambda_{max}} =$	4,0307		

Source: Created by the Author.

Table 34: The Pairwise Comparison Matrix for The Sub-Criteria Based on Investment Main Criterion (After Covid 19 Period)

Investment	Implementation Time	Maintenance and repair cost	System cost	Infrastructure cost
Implementation Time	1,0000	1,1548	0,6710	1,2548
Maintenance and repair cost	0,8660	1,0000	0,4052	0,6818
System cost	1,4903	2,4680	1,0000	1,9874
Infrastructure cost	0,7969	1,4668	0,5032	1,0000

Source: Created by the Author.

Each cell ratio for column total is found in Table 35.

Table 35: Dividing Each Cell by The Total of The Column for Sub-Criteria of Investment Main Criteria (After Covid 19 Period)

Investment	Implementation Time	Maintenance and repair cost	System cost	Infrastructure cost
Implementation Time	0,2408	0,1896	0,2601	0,2548
Maintenance and repair cost	0,2085	0,1642	0,1571	0,1385
System cost	0,3588	0,4053	0,3877	0,4036
Infrastructure cost	0,1919	0,2409	0,1951	0,2031

Source: Created by the Author.

Table 36: The Importance Levels of The Sub-Criteria of The Investment Main Criterion (After Covid 19 Period)

	Importance Levels
Implementation Time	0,2363
Maintenance and repair cost	0,1671
System cost	0,3889
Infrastructure cost	0,2077

Source: Created by the Author.

The importance levels of the sub-criteria that make up the "Investment" main criteria is examined in Table 36 in order to calculate the consistency ratio. The processes in the previous formulas are repeated, and the consistency ratio (CR) and consistency index (CI) data are obtained using the results. The obtained consistency ratio is smaller than 0.1, indicating that the outcome is consistent. The results of the consistency ratio analysis is reported in Table 37.

Table 37: The Consistency Ratio of The Sub-Criteria of The Investment Main Criterion (After Covid 19 Period)

Step 1 Results	**Step 2 Results**		
0,9509	4,0231	**CI =**	0,0079
0,6709	4,0159	**RI =**	0,9000
1,5663	4,0278	**CR =**	0,0088
0,8368	4,0283		
$\lambda_{max} =$	4,0238		

Source: Created by the Author.

In the final section, all the matrix results are averaged, and both local and global importance levels are provided. Table38 summarizes the findings.

Table 38: Converting the Matrix Results by Summing Local Importance Levels and Global Importance Levels (After Covid 19 Period)

		Local Importance Levels	**Global Importance Levels**
mc1	**System**	0,5283	
mc2	**Vendor**	0,1499	
mc3	**Investment**	0,3218	
sc11	**Functionality**	0,2525	0,1334
sc12	**User friendliness**	0,0872	0,0460
sc13	**Flexibility**	0,1303	0,0688
sc14	**Reliability**	0,2649	0,1400
sc15	**Ability to integrate other systems and business processes**	0,1548	0,0818
sc16	**Ability for upgrade in-house**	0,1103	0,0583
sc21	**After sales services (Vendor)**	0,3637	0,0545
sc22	**Vendor reputation**	0,1092	0,0164
sc23	**Vendor technical capability**	0,2888	0,0433
sc24	**Mutual trust with vendor**	0,2383	0,0357
sc31	**Implementation time**	0,2363	0,0761
sc32	**Maintenance and repair cost**	0,1671	0,0538
sc33	**System cost**	0,3889	0,1251
sc34	**Infrastructure cost**	0,2077	0,0668

Source: Created by the Author.

After the Covid 19 period, empirical results indicate that estimating IT due to fully understand SCM performance; among the main criteria, "System" has the highest local importance level with 52,83%, followed by "Investment" with 32,18% local importance level, and finally "Vendor" with 14,99 % local importance level.

According to the local importance level, "Reliability" has the highest value of 26,49% among the sub-criteria of the "System" major criterion, while "User Friendliness" has the lowest value of 8,72%. In regards, "Functionality" has a local importance level of 25.25%, "Flexibility" has a local importance level of 13,03%, "Ability to integrate other systems and business processes" has a local importance level of 15.48%, and "Ability to upgrade in-house" has a local importance level of 11.03%

for the other sub-criteria of the "System" main criteria. In terms of the global importance levels of the factors, this similarity is closer to each other. When the sub-criteria of the "System" main criteria are assessed in terms of global importance level, "Reliability" has 14% and "Functionality" has 13,34%, while "User Friendliness" has 4,60% and "Ability to integrate other systems and business processes" has 5,83%.

Once it relates to the "Vendor" main criteria, the "After sales services (Vendor)" sub-criteria has the biggest rate of 36,37%, while the "Vendor reputation" sub-criteria has the lowest rate of 10,92% when it comes to local importance level. Furthermore, when the local importance level of other "Vendor" sub-criteria is examined, "Vendor technical capability" has a value of 28,88%, and "Mutual trust with vendor" has a value of 23,83%. When the global importance level of sub-criteria of the "Vendor" main criteria is studied, the sub-criteria "After sales services (Vendor)" has a rate of 5,45%, and the sub-criteria "Vendor technical capability" has a rating of 4,33%. On the global importance level, the sub-criteria "Mutual trust with vendor" (3,57%) and "Vendor reputation" (1,64%) have the minimum rate value.

Eventually, while considering the sub-criteria of the "Investment" main criteria, "System cost" (38,89%) has the maximum value for local importance level, whilst also "Maintenance and repair cost" 16,71%) has the minimum. Other sub-criteria have a local importance level of 23,63% for " Implementation time" and 20,77% for "Infrastructure cost." On the other side, among the sub-criteria of the "Investment" main criteria, "System cost" (12,51%) has the highest global importance level, while "Maintenance and repair cost" sub-criteria has the minimum value with 5,38%.

When all sub-criteria are taken into account, the "Reliability" sub-criteria under the "System" main criteria has the highest global important value of 14% while the "Vendor reputation" sub-criteria under the "Vendor" main criteria has the lowest rate of 1,64%.

3.3.3. All Empirical Findings

In this part, all empirical results will be analyzed from the interviews including before Covid 19 and after Covid 19 periods. There are totally 18 (eighteen) interviews.

The processes for analyzing the results are all the same. The first pairwise comparison matrices are created using decision-makers' responses. The geometric averages of the answers are next examined, and the results are finally combined. In Table 39, firstly pairwise comparison is shown related to all main criteria.

Table 39: Pairwise Comparison Matrix for Main Criteria

	System	**Vendor**	**Investment**
System	1,0000	3,9054	1,4903
Vendor	0,2561	1,0000	0,5132
Investment	0,6710	1,9486	1,0000

Source: Created by the Author.

The weight of each cell is given for the total of its own column regarding main criteria in Table 40.

Table 40: Dividing each cell by its own column total (Main criteria)

	System	**Vendor**	**Investment**
System	0,4752	0,5613	0,4415
Vendor	0,1234	0,1458	0,1856
Investment	0,4014	0,2929	0,3729

Source: Created by the Author.

In Table 41, the weight average for each row in Table 40 is summed and the importance level of each main criteria is analyzed.

Table 41: The Importance Levels (Main Criteria)

	The Importance Levels
System	0,4926
Vendor	0,1516
Investment	0,3557

Source: Created by the Author.

To confirm that the importance levels derived in Table 41 are consistent, when consistency ratios are calculated. The consistency ratio is calculated by multiplying the initial data comparison matrix by the importance levels matrix. In the second phase of the consistency ratio computation, the values obtained in step 1 are calculated in accordance with the appropriate importance levels. After obtaining the results of Step 2, the consistency index (CI) and consistency ratio (CR) are generated. Because the resulting consistency ratio is less than 0.1, the acquired data is deemed reliable. The values obtained during the consistency ratio computation method are shown in Table 42.

Table 42: The Consistency Ratio Matrix (Main Criteria)

Step 1 Results	**Step 2 Results**		
1,4975	3,0397	**CI =**	0,0129
0,4566	3,0119	**RI =**	0,5800
1,0765	3,0261	**CR =**	0,0223
λ_{max} =	3,0259		

Source: Created by the Author.

Following the completion of these processes for the main criteria, the same procedure is followed for the sub-criteria for each main criterion. The pairwise comparison matrix for the sub-criteria related to the "System" main criteria is shown in Table 43.

Table 43: The Pairwise Comparison Matrix for Sub-Criteria Related to The System Main Criterion

System	**Functionality**	**User friendliness**	**Flexibility**	**Reliability**	**Ability to integrate other systems and business processes**	**Ability for upgrade in-house**
Functionality	1,0000	2,1279	1,3153	0,6943	1,5410	2,0516
User friendliness	0,4699	1,0000	0,8267	0,3509	0,8603	0,7499

Flexibility	0,7603	1,2096	1,0000	0,5287	0,7966	0,9657
Reliability	1,4403	2,8497	1,8914	1,0000	2,3675	2,5222
Ability to integrate other systems and business processes	0,6489	1,1624	1,2554	0,4224	1,0000	1,5761
Ability for upgrade in-house	0,4874	1,3335	1,0355	0,3965	0,6345	1,0000

Source: Created by the Author.

The weight on each cell to its column total is obtained in Table 44.

Table 44: Dividing Each Cell by The Total of The Column for Sub-Criteria of System Main Criteria

System	**Functionality**	**User friendliness**	**Flexibility**	**Reliability**	**Ability to integrate other systems and business processes**	**Ability for upgrade in-house**
Functionality	0,2080	0,2198	0,1796	0,2046	0,2140	0,2314
User friendliness	0,0978	0,1033	0,1129	0,1034	0,1195	0,0846
Flexibility	0,1582	0,1249	0,1365	0,1558	0,1106	0,1089
Reliability	0,2996	0,2943	0,2582	0,2947	0,3288	0,2845
Ability to integrate other systems and business processes	0,1350	0,1200	0,1714	0,1245	0,1389	0,1778
Ability for upgrade in-house	0,1014	0,1377	0,1414	0,1169	0,0881	0,1128

Source: Created by the Author.

The consistency ratios are used to calculate the important levels, which are provided in Table 45. The first step is to multiply the initial data comparison matrix with the importance level matrix. The consistency ratio is calculated in the second part by comparing the values acquired in the first and second parts, and the ratio is given according to the improved significantly. After the results of step 2, the consistency

index (CI) and consistency ratio (CR) are determined. Because the consistency ratio is less than 0.1, so the findings are consistent.

Table 45: The Importance Levels of The Sub-Criteria of The System Main Criterion

	Importance Levels
Functionality	0,2096
User friendliness	0,1036
Flexibility	0,1325
Reliability	0,2934
Ability to integrate other systems and business processes	0,1446
Ability for upgrade in-house	0,1164

Source: Created by the Author.

The weights found in the consistency ratio formula is presented in Table 46.

Table 46: The Consistency Ratio of The Sub-Criteria of The System Main Criterion

Step 1 Results	**Step 2 Results**		
1,2695	6,0576	**CI =**	0,0092
0,6262	6,0464	**RI =**	1,2400
0,7998	6,0361	**CR =**	0,0074
1,7769	6,0567		
0,8747	6,0488		
0,7019	6,0312		
λ_{max} =	6,0461		

Source: Created by the Author.

A sub-criteria analysis based on another main criterion is undertaken after the processes within the main criteria have been concluded. The pairwise comparison matrix for the sub-criteria associated to the "Vendor" main criteria is shown in Table 47.

Table 47: The Pairwise Comparison Matrix for The Sub-Criteria Based on Vendor Main Criterion

Vendor	After sales services (Vendor)	Vendor reputation	Vendor technical capability	Mutual trust with vendor
After sales services (Vendor)	1,0000	2,9108	0,9977	1,0258
Vendor reputation	0,3435	1,0000	0,2952	0,4187
Vendor technical capability	1,0023	3,3878	1,0000	1,4445
Mutual trust with vendor	0,9748	2,3885	0,6923	1,0000

Source: Created by the Author.

In Table 48, the weights of each cell to its column total is provided.

Table 48: Dividing Each Cell by The Total of The Column for Sub-Criteria of Vendor Main Criteria

Vendor	After sales services (Vendor)	Vendor reputation	Vendor technical capability	Mutual trust with vendor
After sales services (Vendor)	0,3011	0,3005	0,3342	0,2638
Vendor reputation	0,1035	0,1032	0,0989	0,1077
Vendor technical capability	0,3018	0,3497	0,3350	0,3714
Mutual trust with vendor	0,2936	0,2466	0,2319	0,2571

Table 49: The Importance Levels of The Sub-Criteria of The Vendor Main Criterion

	Importance Levels
After sales services (Vendor)	0,2999
Vendor reputation	0,1033
Vendor technical capability	0,3395
Mutual trust with vendor	0,2573

Source: Created by the Author.

The importance levels of the sub-criteria of the main criteria "Vendor" is assessed using the consistency ratio which is shown in Table 49. In the first round, the importance level matrix is multiplied by the initial data comparison matrix. After comparing the ratio to the values obtained in the first round, the consistency ratio is calculated in the second round. In the round 2 results, you may find the consistency index (CI) and consistency ratio (CR). The attained consistency ratio is less than 0.1, demonstrating that the result is trustworthy. Table 50 shows the results of using the consistency ratio calculating method.

Table 50: The Consistency Ratio of The Sub-Criteria of The Vendor Main Criterion

Step 1 Results	**Step 2 Results**		
1,2033	4,0121	**CI =**	0,0035
0,4143	4,0101	**RI =**	0,9000
1,3617	4,0110	**CR =**	0,0039
1,0314	4,0088		
$\lambda_{max} =$	4,0105		

Table 51: The Pairwise Comparison Matrix for The Sub-Criteria Based on Investment Main Criterion

Investment	**Implementation Time**	**Maintenance and repair cost**	**System cost**	**Infrastructure cost**
Implementation Time	1,0000	1,3000	0,7242	1,0265
Maintenance and repair cost	0,7692	1,0000	0,4193	0,6285
System cost	1,3809	2,3847	1,0000	1,6051
Infrastructure cost	0,9742	1,5910	0,6230	1,0000

Source: Created by the Author.

Each cell weight for column total is given in Table 52.

Table 52: Dividing Each Cell by The Total of The Column for Sub-Criteria of Investment Main Criteria

Investment	**Implementation Time**	**Maintenance and repair cost**	**System cost**	**Infrastructure cost**
Implementation Time	0,2425	0,2072	0,2618	0,2409
Maintenance and repair cost	0,1865	0,1593	0,1516	0,1475
System cost	0,3348	0,3800	0,3615	0,3768
Infrastructure cost	0,2362	0,2535	0,2252	0,2347

Source: Created by the Author.

Table 53: The Importance Levels of The Sub-Criteria of The Investment Main Criterion

	Importance Levels
Implementation Time	0,2381
Maintenance and repair cost	0,1612
System cost	0,3633
Infrastructure cost	0,2374

Source: Created by the Author.

In order to compute the consistency ratio, the importance levels of the sub-criteria that make up the "Investment" main criteria are analyzed in Table 53. The previous procedures are repeated, and the results are used to calculate the consistency ratio (CR) and consistency index (CI). The consistency ratio achieved is less than 0.1, signifying that the result is in accordance. Table 54 shows the findings of the consistency ratio analysis.

Table 54: The Consistency Ratio of The Sub-Criteria of The Investment Main Criterion

Step 1 Results	**Step 2 Results**		
0,9545	4,0090	**CI =**	0,0032
0,6459	4,0060	**RI =**	0,9000
1,4576	4,0126	**CR =**	0,0035
0,9522	4,0107		
$\lambda_{max} =$	4,0096		

Source: Created by the Author.

All the matrix findings are averaged in the last part, and both local and global importance levels are supplied. The findings are listed in Table 55.

Table 55: Converting the Matrix Results by Summing Local Importance Levels and Global Importance Levels

		Local Importance Levels	**Global Importance Levels**
mc1	**System**	0,4926	
mc2	**Vendor**	0,1516	
mc3	**Investment**	0,3557	
sc11	**Functionality**	0,2096	0,1032
sc12	**User friendliness**	0,1036	0,0510
sc13	**Flexibility**	0,1325	0,0653
sc14	**Reliability**	0,2934	0,1445
sc15	**Ability to integrate other systems and business processes**	0,1446	0,0712
sc16	**Ability for upgrade in-house**	0,1164	0,0573
sc21	**After sales services (Vendor)**	0,2999	0,0455
sc22	**Vendor reputation**	0,1033	0,0157
sc23	**Vendor technical capability**	0,3395	0,0515
sc24	**Mutual trust with vendor**	0,2573	0,0390
sc31	**Implementation time**	0,2381	0,0847
sc32	**Maintenance and repair cost**	0,1612	0,0574
sc33	**System cost**	0,3633	0,1292
sc34	**Infrastructure cost**	0,2374	0,0845

Source: Created by the Author.

In the last part of the study, all empirical findings related to local and global importance levels are presented. The results show that “System” main is the most significant criteria among other three main criteria regarding with the local importance level with 49,26% weight. The next significant main criteria with the weight 35,57% is “Investment” and the “Vendor” main criteria has the least weight with %15,16.

When it is analyzed, the sub-criteria belong the “System” main criteria, the sub-criteria “Reliability” has the highest weight (29,34%) among other sub-criteria. On the other hand, “User friendliness” has the least weight among others. Respectively, “Functionality” (20,96%): “Ability to integrate other systems and business processes” (14,46%): “Flexibility” (13,25%): and “Ability for upgrade in-house” (11,64%) are presented in context of local importance level values. For measuring the global importance level indicators, the sub-criteria of the “System” main criteria are also calculated, and “Reliability” has 14,45% weight and “Functionality” has 10,32% weight, yet “User friendliness” has the least weight with 5,10%, and “Ability for upgrade in-house” has 5,73% weight.

When it comes to the "Vendor" main criteria, the " Vendor technical capability" sub-criteria has the highest weight of 33,95%, while the "Vendor reputation" sub-criteria has the lowest rate of 10,33%. Furthermore, "After sales services (Vendor)" has a weight of 29,99%, and "Mutual trust with vendor" has a value of 25,73% when the local importance level of other "Vendor" sub-criteria is reviewed. Once the global importance level of sub-criteria of the "Vendor" is examined, the sub-criteria "Vendor technical capability" receives a weight of 5,15%, while the sub-criteria "After sales services (Vendor)" receives a weight of 4,55%. The sub-criteria "Mutual trust with vendor" (3,90%) and "Vendor reputation" (1,57%) have the lowest weight on the global important level.

Finally, while looking at the sub-criteria of the "Investment" main criteria, "System cost" (36,33%) has the highest weight for local importance level, while "Maintenance and repair cost" (16,12%) has the lowest weight. Other sub-criteria, such as "Implementation time" and "Infrastructure cost," have a local importance level of 23,81% and 23,74%, respectively. On the other hand, "System cost" (12,92%) has the highest global importance level among the sub-criteria of the "Investment" main

criteria, while "Maintenance and repair cost" sub-criteria has the lowest weight with 5,74%.

Once all sub-criteria are reviewed, the "System" main criteria's "Reliability" sub-criteria has the highest global importance level of 14,45%, whereas the "Vendor" main criteria's "Vendor reputation" sub-criteria has the lowest weight of 1,57%. Lastly, raw data from the interviews are given in Appendix 2.

3.3.4. Measuring the In-Depth Interviews and Open-Ended Questions

In this study, open-ended questions are prepared and gathered through both in-depth interviews and questionnaire forms in order to understand decision-makers' perceptions and leanings toward IT in their SCM processes and logistics activities, as well as to improve the validity of the analysis results. Questions about business size, personal information such as respondents' roles and experience in their work setting, technical information within the scope of information technologies and supply chain process / logistics activities are addressed to decision makers, in addition, general views on the role of IT on their business performance in the future are among the open-ended questions. There is also question how many years it has been used the current IT system in the company. During the Covid 19 period, participants are also asked to assess their IT capabilities by comparing before and after the Covid 19 on their business flows.

By utilizing the purposeful sampling technique, the interviews were carried out with respondents including managers, seniors or experts from IT, logistics, foreign trade, and R&D departments. Specifically, chosen from these departments as the participants comprehensive knowledge on their field of expertise. Information about decision-maker is presented in Table 56 in terms of the questions asked in the questionnaire form.

Table 56: Demographic Profile of the Decision-Makers

Decision-Makers	Departments	Job Titles	Experience (Years)	Utilization Time of current IT System
1	Logistics	Logistics Expert	2	4
2	Supply Chain and Logistics Division	SC Coordinator	3	5
3	Logistics	Logistics Expert	4	10
4	IT Department	Executive Board Member and IT Manager	25	8
5	Export – Import Department	Export – Import Manager	6	18
6	Export – Import Department	Export – Import Manager	8	10
7	IT Department	IT Executive	3	5
8	IT Department	IT Manager	4	1
9	Logistics Department	Logistics Manager	10	3
10	IT Division	IT Manager	4	3
11	R&D Department	R&D Manager	3	20
12	Logistics Department	Logistics Manager	14	3
13	Logistics Department	Logistics Manager	16	6
14	Foreign Trade Department	Foreign Trade Executive	6	9
15	Logistics Department	Logistics Manager	3	10
16	IT Department	IT Executive	10	5
17	Logistics Department	Logistics Manager	5	5
18	Transportation Department	Transportation Department Executive	10	10

Source: Created by the Author.

As mentioned in the previous part, in-depth interviews were conducted face to face and via zoom teleconference program, and it took approximately 20 – 25 minutes long. Interview responds were noted fully simultaneously.

Furthermore, decision-makers largely stated that IT systems in our country are not well understood and utilized, but that they are aware of these notions. Likewise, the decision-makers agreed that having a mindset of integrating IT systems with

logistics operations and SC activities is critical for firms to operate efficiently. Here are some quotes from respondents on the sectoral assessments and predictions for the IT systems and their operations:

> *In accordance with our supply chain process, choosing correct system is crucial. We use SAP not only in our logistics operations but also in our other functions of business to improve the process. For this reason, system needs to be adopted to company's process correctly as we have other divisions in the oversea. The data also needs to be accurate, fast, and reliable. For instance, even if there is inaccurate data on a simple shipping form, the shipping will be affected negatively. And our supply chain process breaks down.* (Decision-maker 4)

> *In our business, single warehouse system is essential for the logistics operations. The reason is that we always aim for minimizing the logistics costs by integrating our current IT system with our transportation system and foreign trade system. For instance, we can easily track our tucks or other vehicles in ports and customs stations. We also use classic MRP (Material Resource Planning) system as we have wide range product type, and we are one of the biggest suppliers of a multinational firm in Turkey.* (Decision-maker 6)

> *Particularly, we use this program (ODA – ERP program). Because for our supply chain process, we have to be very flexible, and this system lets us to improve the system regarding with the processes. Therefore, the vendor firm (the firm we purchased the system) provides best modules for our business operations in the market. Within this context, we can manage every single operation easily.* (Decision-maker 8)

> *Before we use SAP software program, we were using LOGO program, but when we expand our business and we set up both office and warehouse in Hungry and Tuzla, in 2019 we started to use SAP program, as the operations became more complex. With the SAP modules, we easily linked logistics operations and warehouse management system modules, and we can easily manage the activities from material handling to routing.*(Decision-maker 17)

From the statement, it can be understood that respondents declared how important the systems for their operations within the specific point of views. Moreover, they also stated the assessment for their IT systems during Covid 19 period about the changes on their business transactions, and the quotes are given below:

> *After the Covid 19 outbreak, we have so much loss on cost basis, especially, we have partners, and we supply big volume of goods to abroad on weekly basis. For a short while, we couldn't conduct business, and during this moment we upgrade our IT system with new features. During this period, the degree of dependency towards new IT system has increased.* (Decision-maker 5)
> *We don't have any issues before and after Covid 19, just only in the beginning of the pandemic we had issues related to production capacity. By upgrading our IT systems, we have had overcome the issues relatively. Particularly, we focused on the capacity module for improving the system."* (Decision – maker 10)

There wasn't any problem because of the Covid 19 in terms of our IT systems. However, there is increase right on rates of the fright in Europe and Asia. Business transactions have become expensive. Therefore, our IT system particularly saved us from this situation by providing alternatives. (Decision – maker 12)

After Covid 19, we comprehend the significance of automation. Because of the Covid 19 protocols, some systems and activities have been improved by integrating systems related to packaging and material handling. Some automations have been generated during especially logistics operations. We had to diminish the human factor during these processes and focused on systems." (Decision – maker 17)

During Covid 19, we try to observe the effects of pandemic on our target market. We reanalysed our methods on the target market and integrated location systems to our current IT system. In accordance with the results of the analysis, we implemented forecasting action plan regarding this data analysis. During this process, newly integrated location technologies have made a huge impact on the operations. Thus, we improved service network, particularly on logistics operations. (Decision – maker 18)

Based on the respondents' interviews regarding the impacts of IT systems on their SC process and logistics operations, it is obvious that systems provide various capabilities and opportunities to enrich their business strategies. However, there are some drawback and concerns in terms of financial aspects to have these advanced technologies.

Moreover, in the context of the open-ended questions about evaluating the Covid 10 period, almost each decision-maker declared how it is necessary to have technologies during this period. They all responded that the dependency degree towards technology is getting increase every single moment for their business flows.

3.4. LIMITATIONS AND RECOMMENDATIONS

There are various limitations to the conclusions of this research. First, this study was conducted within organizations in Manisa Industrial Park, Turkey, which limits the sample's representativeness, even though the utilization of various sectors provides fertile ground for the research of exposing distinctions in information technology selection. Secondly, the purposeful sampling procedure focused solely on experts in the field, which may have resulted in a failure to capture the insights and experiences of other clusters such as employees. Future research suggestions that

include other sectors would broaden the breadth and generalizability of the existing results. Apart from these, there were also difficulties to have appointments particularly during Covid 19 period, as most of the organizations refused to have or cancelled their appointments because of the severe measures taken during the Covid 19 period. Some organizations also restricted to share their information under circumstances of classified information. For this reason, some interviews couldn't be attached to the study.

As for recommendations, apart from these parameters, various parameters can be also added to the study. Within this context, the study embodies more extensive processes, including other functions of businesses. Once there are several various sectors are included in the study, however a specific sector would be focused on to reveal the strong points of information technologies on a specific sector.

CONCLUSION

Organizations act in the direction of minimizing their costs due to their objectives and structures, and they always aim to maintain their existence and increase their competitive strength. In line with these objectives, with the guidance of the conditions, the operations from the raw material to the end customer started to be mutual, and organizations decided to act jointly with these common purposes. This collaboration has formed the concept of supply chain. Therefore, the supply chain is considered as one of the main functions in order to survive and expand in a highly competitive environment. Ensuring the holistic efficiency of the supply chain will have positive impacts on each link of the chain. The efficiency of the supply chain also depends on an effective supply chain management. With effective supply chain management, costs will decrease, customer satisfaction will increase, errors will decrease, stocks will decrease, and it will provide many other competitive advantages.

Relationships between firms are formed within the supply chain based on a variety of factors, including competitiveness, product features, services offerings, industry structure, and aspects. Procurement and supply operations are the first and most direct form of interaction in these relationships. Organizations always aim for the right product, right place, right time, right price, right quality, and right quantity when it comes to procurement activities. Supply, on the other hand, is a broad and long-term notion that addresses a variety of requirements and expectations. Organizations also need to be able to supply raw materials for their activities from the right source, at the right time, at a reasonable cost, and with the expected features. Therefore, supplier relations, which is one of the chain relations, is one of the important elements that affect the whole supply chain. The entire supply chain will have a stronger structure with effective supplier relations. Hence, sharing information on products, inventory, logistics, and other aspects of the supply chain between suppliers and retailers will improve the supply chain performance as well as cooperation in planning and ordering.

Organizations are striving to boost their productivity and profitability in the emerging and evolving global economic climate in order to achieve a competitive advantage without falling behind. In addition to these breakthroughs, they must leverage information technology to improve quickly in order to streamline their

complex workflows. Regardless of how expensive advanced information technologies are, it becomes necessary for organizations to develop the most appropriate solutions so that they can make more strategic managerial judgments. Organizations should assess the information gathered in order to determine their market position and plan accordingly. To be able to make evaluations, businesses must be able to forecast the future and set goals for themselves based on previous data, market conditions, competitors, and economic circumstances. They should also make their measurements by making analyzes between the objectives they set and their current position as a result of their activities. They should study the variances and come up with swift remedies to the problems they encounter.

Information technologies, like global commerce, have advanced at a tremendous speed. Organizations that are late in upgrading their old technologies are doomed to fail in their fields. Organizations should adopt the most reliable information technology applications and adapt them in order to avoid falling behind the competition and boost profitability. Businesses can manage their supply chains more efficiently by using these information technology resources, and they can remain competitive by enhancing their profitability. Building information systems isn't enough for organizations. Simultaneously, organizations should always be alert to such technological advances, and keep it going with them in a timely manner, plus practitioners should plan their work according to the goals that have been established for them. Following the implementation of these systems, top management should review the main performance targets, identify inefficiencies, and make the required corrective choices and interventions. In a world where transportation and communication opportunities are swift, senior management must make critical decisions swiftly and put them into action. They will be able to attain this speed solely via the use of information technologies.

Hence, information technologies can be utilized to make performance evaluations in addition to being developed to manage all processes in a systematic way. Experts develop basic and tailor - made solutions for organizations within this aspect. Organizations should invest in these solutions, implement them, and monitor their progress in light of their competitors' practices and operating capacities. In logistics, information flows can be performed continuously, and it is significantly

increasing speed, which is one of the most crucial components of logistics. These enhancements enable not only enhanced performance, but also increase the visibility of logistic data throughout each level of the supply chain. At every level of the logistics process, information systems provide information to the management and related staff. Aside from it though, information systems can also be used to connect activities that are not part of operational procedures. For example, they coordinate with departments such as finance, production, and so on. The multiple and varied processes in logistics, that is a segment of service sector, need for these information systems. Otherwise, it is impossible to plan activities and processes without using such systems.

Meanwhile, big organizations' structured supply chains are extensive. As a result, by coordinating and sharing information among supply chain organizations, the level of uncertainty about demand is reduced, and it is no longer essential to invest heavily in inventory. A setup like this allows for easier planning and lower expenditures. Furthermore, retailer and supplier trust and cooperation allow them to share risks, reduce barriers between businesses, and boost flexibility. It will contribute to the development of new products and shorter market submission periods, which are both competitive advantages. Consumer satisfaction will be offered as a result of meeting customers' needs. When they are assessed in terms of monetary issues, it is expected that cash flows in the chain will be managed, and enterprises' expenses will be reduced while profits rise.

Industry 4.0 has resulted in the emergence of a variety of applications and systems in recent years, that opening the way for the advancement of information technologies. Businesses should keep a close eye on changes and assess how these systems will fit into their own organizational structures as soon as possible. The developments in Industry 4.0 era have also had an important place in supply chain management. Particularly, it is critical for organizations to be integrated in Smart Supply Chain and Logistics 4.0 systems with Industry 4.0 applications. Because the application of digital transformation and smart technology in the supply chain processes and logistics activities will make both organizational structure and business flow more innovative, transparent, and efficient at every stage. According to these changes, individual consumer needs would become closer, decision-making quality

will improve dramatically, and decision-making will become more effective and versatile in the near future.

Because a part of the study's research was conducted during the covid 19 process, it's important to emphasize the impacts of the Covid 19 on both logistics and supply chain activities. The Covid 19 epidemic has had a wide range of consequences on both individuals and institutions. Particularly, nations have concentrated not just on health-related policies, but also on measures that might be adopted in the economic field during the global epidemic period. Moreover, Covid 19 pandemic has had significant impacts on company management and working habits, as well as on social and economic life, and has unlocked the way of transformation. Supply chains have been impacted in regional, national, and worldwide lockdown processes as a result of the Covid 19 outbreak. The impacts of the pandemic can be seen most clearly in the supply chain and stock management. Many issues have arisen throughout this process, from the supply of raw materials to the end consumer. With the global spread of the epidemic, organizations importing materials from other countries took action and felt compelled to purchase additional materials from their suppliers in countries where the pandemic had been detected in order to secure future production continuity. Consequently, the supply chain's uncertainty has grown as material delivery periods have stretched. From the findings of the study, it is understood that many organizations pay much more attention on their information technologies during this period.

The contribution of this study to the literature is that organizations will benefit significantly from assessments of the impact of information technology on the supply chain when making new decisions. Although there is a great deal of interest in the concepts of information technologies and their implications for supply chain management, these approaches and methods are theoretically debated in the literature, and there is no definitive agreement on how these new information technologies should be reflected in the supply chain framework before and after the Covid 19 process. Furthermore, these concepts have not been fully evaluated in Turkey, both in terms of conceptual and application frameworks. Within the framework of this thesis, it is to classify and choose the main and sub-criteria that organizations use to acquire information technologies for supply chain performance. To achieve this purpose, pilot tests were conducted first to identify the main criteria and sub-criteria that would be

included in the analysis, by having exchange of views through mind mapping, and then the concept of the model was finalized after receiving feedback from a variety of academics.

Due to the complexities of information technology selection options, the proposed model is then designated. When dealing with decision-making difficulties involving subjective data, multi-criteria decision-making procedures make it easier to reach a conclusion. In the proposed model, a hierarchical structure is first developed while considering the information technology selection assessment question. Within this structure, main criteria and sub-criteria were determined. There are three main criteria and fourteen sub-criteria. Evaluations were conducted on eighteen different companies in Manisa Industrial Park. One qualified decision maker from each company performed a pairwise comparison of the criteria. AHP method was carried out on each decision maker. Consistency control was made according to the AHP method, and it was found to be consistent. The averages of the results of the AHP method were also taken.

According to results, for the measurement of information technologies for supply chain management performance, the "System" main criteria has the highest importance level after Covid 19 period as well as before Covid 19. While the order of the three main criteria in terms of importance levels haven't changed in both periods; the local importance level of the "System" main criteria before Covid 19 period is 66.85%, and after Covid 19 period is 52.83%. In addition, the local importance level of the main criteria "Vendor" before Covid 19 period is 11.70%, yet after Covid 19 period is 14.99%. Lastly, "Investment" main criteria is determined in terms of local importance level; before Covid 19, it is 21.45%, and after Covid 19, it is 32.18%.

Considering the sub-criteria of the "System" main criteria, before Covid 19 period, the highest value is "Functionality" with 32%, while "Reliability" is the highest valued sub-criteria with 26.49% after the Covid 19 period. On the other hand, the difference between the two periods is not great since the "Functionality" sub-criteria has close importance level with the "Reliability" sub-criteria with 25.25% after Covid 19 period. Although there are differences before and after Covid 19 periods between the "Functionality" and "Reliability" sub-criteria, the local importance levels of the other four sub-criteria are similar to each other.

When the sub-criteria of the “Investment” main criteria is measured, before Covid 19 period, the highest valued sub-criteria is "Implementation Time" with 49.05%, while "System cost" is the highest valued sub-criteria with 38.89% after Covid 19 period. When both periods are considered separately, the differences between the sub-criteria of the main criterion of “Investment” showed significant changes. The importance level of the “Implementation time " sub-criteria decreased by approximately 25 points, an increase of approximately 7 points in the importance level of the “Maintenance and repair cost” sub-criteria, there is an increase of approximately 13 points in the importance level of the “System cost” sub-criteria, and an increase of approximately 5 points is observed in the importance level of the sub-criteria “Infrastructure cost”.

Once the sub-criteria of the “Vendor” main criteria is evaluated, before the Covid 19 period, the local importance levels of the four sub-criteria were close to each other. The biggest absolute percentage difference is observed as 4 points in the "Vendor Technical Capability" sub-criteria.

In conclusion, it is also supported by the responds from interviews, organizations must carefully identify their future objectives and plans, so they adopt and implement them, and make full use of information technologies while doing so in order to be a leader in the field. Particularly, after Covid 19 period, it is understood that organizations are depending on information technologies more and more. They should assess the outcomes of their efforts and the extent to which their objectives and strategies have been achieved.

Managerial Implications

By examining the experimental correlations between IT, supply chain integration, and supply chain performance within the context of the AHP technique, this research contributes to the literature on SCM from a theoretical standpoint. The findings demonstrate that businesses can employ information technologies to enhance the operation of their supply chains. By producing high-quality data and information for the supply chains of the organizations in the study, the usage of information technologies enhances information sharing, particularly before and after the Covid 19

period. In perspective of this, this study investigates how firms might use IT for a long time. Due to the fierce competition in the industries and the unstable and unpredictable nature of international trade, success in contemporary business nowadays depends mostly on the use of information technologies.

This study has several ramifications for businesses that rely on IT to improve the efficiency of their supply chain processes. Given the critical role of supply chain integration for the various industries, the results assist decision-makers in recognizing the importance of IT implementation and the contribution of IT to improve SCM. A company with insufficient internal integration won't be able to flow information or work together with its supply chain partners. To enhance the effectiveness of their supply chains, managers should establish strong relationships that include the integration of suppliers and customers, information sharing with partners in the supply chain, strategic partnerships with suppliers, and operational coordination with customers. Thus, it is highly possible by using advanced IT.

The use of IT will assist business decision-makers in evaluating the effectiveness of their latest trading and business circumstances, as well as in improving internal operations to be more functionally adaptive. This will enhance the performance of the supply chain, which is measured by three criteria in the current research: system, vendor, and investment.

By using supply chain performance as a lever for the effect of information technologies on supply chain performance to strengthen their consistency, this research provides a connection between the usage of information technologies and the establishment of competitive advantage for the organizations

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APPENDICES

APPENDIX 1: Questionnare Form

LOJİSTİK BİLGİ SİSTEMLERİ DEĞERLENDİRME FORMU

Sayın Katılımcı,

İşletmenin ihtiyaç duyduğu kurumsal kaynak yazılımı seçim sürecinde etkili olan faktörlerin ağırlıklarını saptamak amacıyla yapılan bu ankete katılmanız, araştırmada doğru bilgiler elde etme bakımından son derece önemlidir. Elde edilecek bilgiler, GİZLİ tutulacak olup; sadece bilimsel amaçlarla kullanılacaktır. Talep etmeniz durumunda hazırlanacak makale sizlere de gönderilecektir. İşbirliğiniz ve katkılarınız için teşekkür eder, saygılar sunarız.

Öğr. Gör. Sezai Bahar

1	Eşit öneme sahip
2	Biraz önemli
3	Önemli
4	Daha önemli
5	Kesinlikle daha önemli

Örnekler

Soru1	X	4	A	B		

A kriteri B den **daha önemlidir**. 4 ise bu önem seviyesini göstermektedir.

Soru 2			A	B	X	2

Yukarıdaki örnek B kriterinin A dan **biraz önemli** olduğunu göstermektedir. Tereddüt ettiğiniz durumda birden fazla değer belirtebilirsiniz.

Aşağıdaki tabloda, her soru satırında yer alan iki faktörü kendi içinde karşılaştırıp önemli olanı işaretleyiniz ve yanındaki kutucuğa buna ilişkin bir önem puanı yazınız. Kriterlerin neyi ifade ettiğine dair kısa açıklamalar aşağıdaki gibidir.

Ana Kriterler

- **Sistem:** Firmaların firma içinde ve dışında olan müşteri, sipariş ve envanter bilgilerinin saklanmasını, gerektiğinde çıkartılıp kullanılabilmesinin; müşteri ve tedarikçiye göre stok planlamalarının, talep tahminlerinin ve strateji planlamalarının; her türlü iş akışının koordinasyonunun (taşımacılık, depolama, gümrükleme gibi) sağlanmasında ve bu tüm bu faaliyetler sırasında ve sonrasında müşteri hizmet düzeyinin, taşıyıcıların ve sistem performansının kontrolünün yapılmasını sağlayan; kapsamlı sistemler olarak tanımlanmaktadır.
  - **İşlevsellik:** Bu kapsamda; sistem içindeki gerekli modüllerin ve yapıların elverişli olması, sistemdeki parametre düzenlemesi, sistemin yüksek işlevsel uygunluğu, sistemin çoklu para birimi, çoklu dil desteği gibi özellikler taşıması, sistemin izin yönetimi, sistemin veri tabanı koruması gibi işlevleri içermektedir.
  - **Kullanım Rahatlığı:** Sistemin kullanım ve öğrenme kolaylığı veya rahatlığını sağlaması. Örneğin; grafik arayüzü, adım adım atılacak komut düzeyi, yardımcı bir kitabın veya düzeneğin oluşturulması, online yardım veya öğrenme gibi.
  - **Esneklik:** Özel müşteri segmentlerinin veya isteklerinin karşılanmasında bilgi süreçlerine ve yapılarına sistemin adapte olması. Örneğin; sistemi geliştirme (upgrade) yeterliliği, sistemin kendi içinde veya diğer sistemlerle birleşmesi.
  - **Güvenilirlik:** Sistemin tutarlılığı ve istikrar göstermesi, sistemin kendisini iyileştirme yeteneği. Örneğin; otomatik yedekleme veya iyileştirme.
  - **İş Süreçleri Ve Diğer Sistemlerle Uyum:** Sistemin iş süreçlerinin aşamalarında gösterdiği katkısı ve diğer kullanılan sistemlerle uyum göstermesi. Bilginin kurum içinde etkin bir biçimde sistemle uyumlu kullanılabilmesi.
  - **Kurum İçi Geliştirme Olanakları:** Sistemin kurum içi geliştirme ve uygulama kolaylığı.
- **Tedarikçi (Yazılımcı Firma):** Bir ürün ya da hizmetin sunulabilmesi için firmaya sistem yazılımı ve donanımı sağlayan kurumlardır.

- **Satış Sonrası Tedarikçi (Yazılımcı Firma) Desteği:** Sistemin tedarikçisi tarafından sağlanan garanti hizmeti, danışmanlık, oryantasyon (eğitim): online hizmetleri gibi destek faaliyetleri.
- **Tedarikçinin (Yazılımcı Firma) İtibarı:** Yazılımcı firmanın sektörde iyi bir izlenim bırakması; örneğin taahhüdünü zamanında yerine getirmesi, ödemelerini zamanında yapması.
- **Tedarikçinin (Yazılımcı Firma) Teknik Yeterliliği:** Tedarikçinin teknik anlamda ar-ge, teknik destek veya sistem kurulum aşamalarındaki yeterliliği veya kabiliyeti.
- **Tedarikçilerle (Yazılımcı Firma) Oluşturulan Karşılıklı Güven:** Bir takım ortak bilgilerin firma içindeki işlevler arasında paylaşılması. Örneğin; müşteri sipariş bilgisi veya stok seviyesi bilgilerinin paylaşılabilmesi gibi.

- **Yatırım:** Belirli bir kaynağın ya da değerin, gelir sağlamak amacıyla kalıcı bir biçimde kullanılmasıdır.
  - **Uygulama Zamanı:** Sistemin yapılabilirlik etüdünün zaman olarak ifadesi. Örneğin, eski sistemle veya yöntemlerle karşılaştırılarak sistemin ne kadar süre zarfı içinde uygulanacağının raporlanması veya kullanılabilir hale getirilmesi.
  - **Bakım Onarım Maliyeti:** Sistemin bakımı veya teknik arıza durumlarında ayrılan bütçe. Örneğin; sistem için ayrılan yıllık bakım bütçesi.
  - **Sistem Maliyeti:** Sistemin kurulumu, sistemin kullanılabilmesi için tasarlanan eğitimi veya proje adı altında oluşturulması için ayrılan bütçe**.**
  - **Alt Yapı Giderleri:** Sistemin alt yapısının oluşturulması için ayrılan bütçe. Sistem için kullanılabilecek donanım veya diğer yazılım giderleri (intranet/extranet gibi).

Soru1			Sistem	Tedarikçi (Yazılımcı Firma)		
Soru2			Sistem	Yatırım		
Soru3			Tedarikçi (Yazılımcı Firma)	Yatırım		

Soru1			İşlevsellik	Kullanım Rahatlığı		
Soru2			İşlevsellik	Esneklik		
Soru3			İşlevsellik	Güvenilirlik		
Soru4			İşlevsellik	İş Süreçleri Ve Diğer Sistemlerle Uyum		
Soru5			İşlevsellik	Kurum İçi Geliştirme Olanakları		
Soru6			Kullanım Rahatlığı	Esneklik		
Soru7			Kullanım Rahatlığı	Güvenilirlik		
Soru8			Kullanım Rahatlığı	İş Süreçleri Ve Diğer Sistemlerle Uyum		
Soru9			Kullanım Rahatlığı	Kurum İçi Geliştirme Olanakları		
Soru10			Esneklik	Güvenilirlik		
Soru11			Esneklik	İş Süreçleri Ve Diğer Sistemlerle Uyum		
Soru12			Esneklik	Kurum İçi Geliştirme Olanakları		
Soru13			Güvenilirlik	İş Süreçleri Ve Diğer Sistemlerle Uyum		
Soru14			Güvenilirlik	Kurum İçi Geliştirme Olanakları		
Soru15			İş Süreçleri Ve Diğer Sistemlerle Uyum	Kurum İçi Geliştirme Olanakları		

Soru1			Satış Sonrası Tedarikçi (Yazılımcı Firma) Desteği	Tedarikçinin (Yazılımcı Firma) İtibarı		
Soru2			Satış Sonrası Tedarikçi (Yazılımcı Firma) Desteği	Tedarikçinin (Yazılımcı Firma) Teknik Yeterliliği		
Soru3			Satış Sonrası Tedarikçi (Yazılımcı Firma) Desteği	Tedarikçilerle (Yazılımcı Firma) Oluşturulan Karşılıklı Güven		

Soru4			Tedarikçinin (Yazılımcı Firma) İtibarı	Tedarikçinin (Yazılımcı Firma) Teknik Yeterliliği		
Soru5			Tedarikçinin (Yazılımcı Firma) İtibarı	Tedarikçilerle (Yazılımcı Firma) Oluşturulan Karşılıklı Güven		
Soru6			Tedarikçinin (Yazılımcı Firma) Teknik Yeterliliği	Tedarikçilerle (Yazılımcı Firma) Oluşturulan Karşılıklı Güven		

Soru1			Uygulama Zamanı	Bakım Onarım Maliyeti		
Soru2			Uygulama Zamanı	Sistem Maliyeti		
Soru3			Uygulama Zamanı	Alt Yapı Giderleri		
Soru4			Bakım Onarım Maliyeti	Sistem Maliyeti		
Soru5			Bakım Onarım Maliyeti	Alt Yapı Giderleri		
Soru6			Sistem Maliyeti	Alt Yapı Giderleri		

İşletme büyüklüğü:

Çalışan sayısı:

İşletmedeki Göreviniz: .....

Kaç yıldır bu görevi yapmaktasınız?: ....

Kaç yıldır şirketinizde bir IT sistemi var?

Şirketinizde IT sistemini yöneten bir departman / birim / yönetici var mı?

Kullandığınız bilgi sistemi?

Kullandığınız bilgi sistemi ile alakalı olarak Covid-19 öncesi ve sonrası değerlendirme yapabilir misiniz? Örneğin Covid 19 sürecinde bilgi sisteminize daha fazla kaynak ayırarak geliştirmek gibi.

APPENDIX 2: Raw Data from the Interviews

			Firm 1	Firm 2	Firm 3
Q1	System	Vendor	3,0000	5,0000	5,0000
Q2	System	Investment	2,0000	4,0000	5,0000
Q3	Vendor	Investment	3,0000	5,0000	0,2500
Q1	Functionality	User friendliness	5,0000	4,0000	5,0000
Q2	Functionality	Flexibility	0,2500	3,0000	5,0000
Q3	Functionality	Reliability	0,2000	3,0000	5,0000
Q4	Functionality	Ability to integrate other systems and business processes	5,0000	4,0000	5,0000
Q5	Functionality	Ability for upgrade in-house	4,0000	1,0000	5,0000
Q6	User friendliness	Flexibility	4,0000	0,3333	4,0000
Q7	User friendliness	Reliability	0,2000	0,2500	0,2500
Q8	User friendliness	Ability to integrate other systems and business processes	4,0000	1,0000	0,2500
Q9	User friendliness	Ability for upgrade in-house	0,2500	0,2500	4,0000
Q10	Flexibility	Reliability	4,0000	0,2500	0,2500
Q11	Flexibility	Ability to integrate other systems and business processes	4,0000	0,2500	0,2500
Q12	Flexibility	Ability for upgrade in-house	4,0000	0,2500	4,0000
Q13	Reliability	Ability to integrate other systems and business processes	4,0000	0,3333	4,0000
Q14	Reliability	Ability for upgrade in-house	4,0000	0,3333	4,0000
Q15	Ability to integrate other systems and business processes	Ability for upgrade in-house	3,0000	0,5000	4,0000
Q1	After sales services **(**Vendor**)**	Vendor reputation	0,2500	5,0000	5,0000
Q2	After sales services **(**Vendor**)**	Vendor technical capability	0,2000	5,0000	5,0000
Q3	After sales services **(**Vendor**)**	Mutual trust with vendor	0,2500	5,0000	0,2500
Q4	Vendor reputation	Vendor technical capability	0,2500	0,3333	0,2500
Q5	Vendor reputation	Mutual trust with vendor	0,2000	4,0000	0,2500
Q6	Vendor technical capability	Mutual trust with vendor	0,2500	2,0000	0,2500
Q1	Implementation Time	Maintenance and repair cost	3,0000	0,2500	0,2000
Q2	Implementation Time	System cost	0,2500	0,2500	0,2000
Q3	Implementation Time	Infrastructure cost	0,3333	0,2000	4,0000
Q4	Maintenance and repair cost	System cost	0,3333	4,0000	0,2500
Q5	Maintenance and repair cost	Infrastructure cost	0,2500	4,0000	4,0000
Q6	System cost	Infrastructure cost	5,0000	0,3333	4,0000

			Firm 4	Firm 5	Firm 6
Q1	System	Vendor	5,0000	3,0000	5,0000
Q2	System	Investment	0,2500	2,0000	4,0000
Q3	Vendor	Investment	0,2000	3,0000	5,0000
Q1	Functionality	User friendliness	0,3333	5,0000	4,0000
Q2	Functionality	Flexibility	0,2500	0,2500	3,0000
Q3	Functionality	Reliability	0,2000	0,2000	3,0000
Q4	Functionality	Ability to integrate other systems and business processes	3,0000	5,0000	4,0000
Q5	Functionality	Ability for upgrade in-house	4,0000	4,0000	1,0000
Q6	User friendliness	Flexibility	0,2500	4,0000	0,3333
Q7	User friendliness	Reliability	0,2000	0,2000	0,2500
Q8	User friendliness	Ability to integrate other systems and business processes	4,0000	4,0000	1,0000
Q9	User friendliness	Ability for upgrade in-house	3,0000	0,2500	0,2500
Q10	Flexibility	Reliability	0,2000	4,0000	0,2500
Q11	Flexibility	Ability to integrate other systems and business processes	4,0000	4,0000	0,2500
Q12	Flexibility	Ability for upgrade in-house	4,0000	4,0000	0,2500
Q13	Reliability	Ability to integrate other systems and business processes	5,0000	4,0000	0,3333
Q14	Reliability	Ability for upgrade in-house	5,0000	4,0000	0,3333
Q15	Ability to integrate other systems and business processes	Ability for upgrade in-house	0,3333	3,0000	0,5000
Q1	After sales services **(**Vendor**)**	Vendor reputation	4,0000	0,2500	5,0000
Q2	After sales services **(**Vendor**)**	Vendor technical capability	0,2000	0,2000	5,0000
Q3	After sales services **(**Vendor**)**	Mutual trust with vendor	0,2000	0,2500	5,0000
Q4	Vendor reputation	Vendor technical capability	0,2500	0,2500	0,3333
Q5	Vendor reputation	Mutual trust with vendor	0,2000	0,2000	4,0000
Q6	Vendor technical capability	Mutual trust with vendor	1,0000	0,2500	2,0000
Q1	Implementation Time	Maintenance and repair cost	3,0000	3,0000	0,2500
Q2	Implementation Time	System cost	4,0000	0,2500	0,2500
Q3	Implementation Time	Infrastructure cost	4,0000	0,3333	0,2000
Q4	Maintenance and repair cost	System cost	0,3333	0,3333	4,0000
Q5	Maintenance and repair cost	Infrastructure cost	0,2500	0,2500	4,0000
Q6	System cost	Infrastructure cost	0,2500	5,0000	0,3333

			Firm 7	Firm 8	Firm 9
Q1	System	Vendor	5,0000	4,0000	5,0000
Q2	System	Investment	5,0000	1,0000	5,0000
Q3	Vendor	Investment	0,2500	0,2500	0,2000
Q1	Functionality	User friendliness	5,0000	3,0000	5,0000
Q2	Functionality	Flexibility	5,0000	0,3333	5,0000
Q3	Functionality	Reliability	5,0000	0,2500	1,0000
Q4	Functionality	Ability to integrate other systems and business processes	5,0000	2,0000	1,0000
Q5	Functionality	Ability for upgrade in-house	5,0000	2,0000	1,0000
Q6	User friendliness	Flexibility	4,0000	0,2500	0,2500
Q7	User friendliness	Reliability	0,2500	0,5000	0,2500
Q8	User friendliness	Ability to integrate other systems and business processes	0,2500	1,0000	0,2000
Q9	User friendliness	Ability for upgrade in-house	4,0000	2,0000	0,2000
Q10	Flexibility	Reliability	0,2500	0,2500	0,2500
Q11	Flexibility	Ability to integrate other systems and business processes	0,2500	0,5000	1,0000
Q12	Flexibility	Ability for upgrade in-house	4,0000	1,0000	1,0000
Q13	Reliability	Ability to integrate other systems and business processes	4,0000	2,0000	5,0000
Q14	Reliability	Ability for upgrade in-house	4,0000	2,0000	5,0000
Q15	Ability to integrate other systems and business processes	Ability for upgrade in-house	4,0000	3,0000	4,0000
Q1	After sales services **(**Vendor**)**	Vendor reputation	5,0000	3,0000	5,0000
Q2	After sales services **(**Vendor**)**	Vendor technical capability	5,0000	1,0000	1,0000
Q3	After sales services **(**Vendor**)**	Mutual trust with vendor	0,2500	1,0000	5,0000
Q4	Vendor reputation	Vendor technical capability	0,2500	0,5000	0,2000
Q5	Vendor reputation	Mutual trust with vendor	0,2500	1,0000	0,2500
Q6	Vendor technical capability	Mutual trust with vendor	0,2500	1,0000	5,0000
Q1	Implementation Time	Maintenance and repair cost	0,2000	0,5000	5,0000
Q2	Implementation Time	System cost	0,2000	1,0000	5,0000
Q3	Implementation Time	Infrastructure cost	4,0000	1,0000	5,0000
Q4	Maintenance and repair cost	System cost	0,2500	0,3333	0,2500
Q5	Maintenance and repair cost	Infrastructure cost	4,0000	0,5000	0,2500
Q6	System cost	Infrastructure cost	4,0000	1,0000	4,0000

			Firm 10	Firm 11	Firm 12
Q1	System	Vendor	4,0000	5,0000	5,0000
Q2	System	Investment	3,0000	4,0000	4,0000
Q3	Vendor	Investment	3,0000	0,2500	0,2500
Q1	Functionality	User friendliness	1,0000	4,0000	5,0000
Q2	Functionality	Flexibility	3,0000	1,0000	5,0000
Q3	Functionality	Reliability	3,0000	3,0000	3,0000
Q4	Functionality	Ability to integrate other systems and business processes	4,0000	3,0000	4,0000
Q5	Functionality	Ability for upgrade in-house	4,0000	3,0000	4,0000
Q6	User friendliness	Flexibility	0,2500	0,5000	0,2000
Q7	User friendliness	Reliability	0,2500	0,3333	0,2000
Q8	User friendliness	Ability to integrate other systems and business processes	1,0000	2,0000	0,2500
Q9	User friendliness	Ability for upgrade in-house	0,2500	0,5000	0,2000
Q10	Flexibility	Reliability	0,2500	2,0000	0,2500
Q11	Flexibility	Ability to integrate other systems and business processes	0,2500	3,0000	0,2500
Q12	Flexibility	Ability for upgrade in-house	4,0000	2,0000	0,2000
Q13	Reliability	Ability to integrate other systems and business processes	4,0000	3,0000	4,0000
Q14	Reliability	Ability for upgrade in-house	4,0000	1,0000	5,0000
Q15	Ability to integrate other systems and business processes	Ability for upgrade in-house	4,0000	0,3333	0,2500
Q1	After sales services **(**Vendor**)**	Vendor reputation	4,0000	1,0000	5,0000
Q2	After sales services **(**Vendor**)**	Vendor technical capability	1,0000	2,0000	5,0000
Q3	After sales services **(**Vendor**)**	Mutual trust with vendor	0,2500	3,0000	0,2500
Q4	Vendor reputation	Vendor technical capability	0,2500	0,5000	0,2000
Q5	Vendor reputation	Mutual trust with vendor	0,2500	3,0000	0,2500
Q6	Vendor technical capability	Mutual trust with vendor	5,0000	3,0000	0,2000
Q1	Implementation Time	Maintenance and repair cost	4,0000	3,0000	5,0000
Q2	Implementation Time	System cost	4,0000	3,0000	0,2000
Q3	Implementation Time	Infrastructure cost	4,0000	3,0000	5,0000
Q4	Maintenance and repair cost	System cost	0,2500	2,0000	0,2000
Q5	Maintenance and repair cost	Infrastructure cost	0,2500	2,0000	0,2500
Q6	System cost	Infrastructure cost	0,2500	2,0000	5,0000

			Firm 13	Firm 14	Firm 15
Q1	System	Vendor	2,0000	2,0000	4,0000
Q2	System	Investment	0,3333	2,0000	2,0000
Q3	Vendor	Investment	0,2500	3,0000	0,3333
Q1	Functionality	User friendliness	0,3333	4,0000	3,0000
Q2	Functionality	Flexibility	0,3333	2,0000	4,0000
Q3	Functionality	Reliability	2,0000	2,0000	0,2500
Q4	Functionality	Ability to integrate other systems and business processes	3,0000	3,0000	1,0000
Q5	Functionality	Ability for upgrade in-house	3,0000	3,0000	2,0000
Q6	User friendliness	Flexibility	1,0000	0,5000	0,5000
Q7	User friendliness	Reliability	0,5000	4,0000	0,2000
Q8	User friendliness	Ability to integrate other systems and business processes	2,0000	3,0000	0,2500
Q9	User friendliness	Ability for upgrade in-house	3,0000	3,0000	0,3333
Q10	Flexibility	Reliability	2,0000	4,0000	0,2500
Q11	Flexibility	Ability to integrate other systems and business processes	3,0000	4,0000	0,3333
Q12	Flexibility	Ability for upgrade in-house	3,0000	4,0000	0,2500
Q13	Reliability	Ability to integrate other systems and business processes	2,0000	0,5000	4,0000
Q14	Reliability	Ability for upgrade in-house	3,0000	0,5000	4,0000
Q15	Ability to integrate other systems and business processes	Ability for upgrade in-house	2,0000	1,0000	3,0000
Q1	After sales services **(**Vendor**)**	Vendor reputation	4,0000	3,0000	4,0000
Q2	After sales services **(**Vendor**)**	Vendor technical capability	4,0000	0,2000	3,0000
Q3	After sales services **(**Vendor**)**	Mutual trust with vendor	2,0000	3,0000	0,5000
Q4	Vendor reputation	Vendor technical capability	2,0000	0,2000	0,3333
Q5	Vendor reputation	Mutual trust with vendor	1,0000	0,5000	0,5000
Q6	Vendor technical capability	Mutual trust with vendor	0,5000	2,0000	0,3333
Q1	Implementation Time	Maintenance and repair cost	0,5000	3,0000	0,5000
Q2	Implementation Time	System cost	0,2500	0,5000	1,0000
Q3	Implementation Time	Infrastructure cost	0,5000	5,0000	1,0000
Q4	Maintenance and repair cost	System cost	0,3333	0,5000	0,2500
Q5	Maintenance and repair cost	Infrastructure cost	0,5000	3,0000	3,0000
Q6	System cost	Infrastructure cost	3,0000	5,0000	4,0000

			Firm 16	Firm 17	Firm 18
Q1	System	Vendor	4,0000	5,0000	4,0000
Q2	System	Investment	0,3333	0,2500	0,2500
Q3	Vendor	Investment	0,2000	0,2500	0,2000
Q1	Functionality	User friendliness	4,0000	4,0000	3,0000
Q2	Functionality	Flexibility	0,3333	4,0000	4,0000
Q3	Functionality	Reliability	0,3333	0,2500	0,2000
Q4	Functionality	Ability to integrate other systems and business processes	0,3333	0,3333	0,2500
Q5	Functionality	Ability for upgrade in-house	1,0000	4,0000	4,0000
Q6	User friendliness	Flexibility	0,5000	5,0000	5,0000
Q7	User friendliness	Reliability	0,2500	0,2500	0,2000
Q8	User friendliness	Ability to integrate other systems and business processes	0,3333	0,3333	0,2000
Q9	User friendliness	Ability for upgrade in-house	0,2500	3,0000	0,2500
Q10	Flexibility	Reliability	2,0000	0,3333	0,2000
Q11	Flexibility	Ability to integrate other systems and business processes	2,0000	0,3333	0,2000
Q12	Flexibility	Ability for upgrade in-house	0,3333	4,0000	0,2500
Q13	Reliability	Ability to integrate other systems and business processes	0,3333	4,0000	5,0000
Q14	Reliability	Ability for upgrade in-house	0,3333	4,0000	5,0000
Q15	Ability to integrate other systems and business processes	Ability for upgrade in-house	3,0000	4,0000	5,0000
Q1	After sales services **(**Vendor**)**	Vendor reputation	4,0000	5,0000	5,0000
Q2	After sales services **(**Vendor**)**	Vendor technical capability	4,0000	5,0000	0,2500
Q3	After sales services **(**Vendor**)**	Mutual trust with vendor	3,0000	5,0000	3,0000
Q4	Vendor reputation	Vendor technical capability	0,3333	0,2500	0,2000
Q5	Vendor reputation	Mutual trust with vendor	0,5000	0,3333	0,2000
Q6	Vendor technical capability	Mutual trust with vendor	3,0000	4,0000	4,0000
Q1	Implementation Time	Maintenance and repair cost	4,0000	0,3333	0,3333
Q2	Implementation Time	System cost	3,0000	0,2000	0,3333
Q3	Implementation Time	Infrastructure cost	3,0000	0,2000	0,2000
Q4	Maintenance and repair cost	System cost	0,3333	0,2500	0,3333
Q5	Maintenance and repair cost	Infrastructure cost	0,3333	0,2500	0,2000
Q6	System cost	Infrastructure cost	3,0000	5,0000	0,2500