A CASE STUDY WITH SOA ON SUPPLY CHAIN PROCESS

IN TURKISH AUTOMOTIVE INDUSTRY

A MASTER'S THESIS

in

Computer Engineering

Atılım University

by

GONCA GÖKÇE MENEKŞE

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A CASE STUDY WITH SOA ON SUPPLY CHAIN PROCESS

IN TURKISH AUTOMOTIVE INDUSTRY

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IN

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Approval of the Graduate School of Natural and Applied Sciences, Atılım University.

Prof. Dr. İbrahim AKMAN

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I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

Prof. Dr. İbrahim AKMAN

Head of Department

This is to certify that we have read the thesis "A Case Study with SOA on Supply Chain Process in Turkish Automotive Industry" submitted by "Gonca Gökçe MENEKŞE" and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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Gonca Gökçe MENEKŞE

ABSTRACT

A CASE STUDY WITH SOA ON SUPPLY CHAIN PROCESS

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MENEKŞE, Gonca Gökçe

M.Sc., Computer Engineering Department

Supervisor: Instr. Aylin AKÇA OKAN

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Automotive industry has an important role in Turkish economy. Especially, it is considered that many automotive brands make investments in Turkey and it increases the process intensity in this industry. Since there is no base production in our country, there are many distributors for different automotive brands. These distributors organize many sub processes like procurement from main source, distribution, service, after sales service.

Spare part supply is the most important part of these processes. There is a heavy supply chain process which starts from main source and ends at domestic vendors and other automotive firms.

This thesis considers two main problems of Supply Chain Management (SCM) of the automotive industry. First one is; different software platforms are used by vendors which are located at different locations, so this causes poor data synchronization of stock and results is loss of time, labor and data.

Second problem is; logistics, stock movements and local stock plan processes should be synchronized to coordinate with each other and work together as an integrated service background. This causes planning failures and loss of time, money and lack of customer satisfaction.

Today, if the distributor firms which manage these processes in automotive industry are studied, it can be seen that there is not a specific solution for modeling the overall services or different positioned solutions cannot synchronously work together.

The main purpose of this thesis is to implement the Service Oriented Architecture (SOA) approach to the processes which includes these two problems and modeling these processes with the perspective of SOA. Also, within the thesis there exists an application presented which includes sub processes like order, stock and database and web services.

As a result, a service oriented and modern approach has been presented to spare part supply sector. A solution offer and academic research was gained to the literature. A service based complete solution which covers the all roles of SCM is presented. In addition, statistical evaluations of; comparison of existing solutions, survey results and before & after comparison values of concept is given.

Keywords: Service, Software Architecture, SOA, XML, Web Service, Supply Chain Management, Automotive Industry

ÖZ
TÜRK OTOMOTİV SEKTÖRÜNDE YEDEK PARÇA TEDARİĞİ SÜRECİNE YÖNELİK SOA VAKA ÇALIŞMASI

MENEKŞE, Gonca Gökçe

Yüksek Lisans, Bilgisayar Mühendisliği Bölümü

Tez Yöneticisi: Öğr. Gör. Aylin AKÇA OKAN

Ekim 2011, 98 sayfa

Otomotiv sektörü ülkemiz ekonomisinde önemli lokomotif sektörlerden biridir. Özellikle birçok markanın da ülkemizde yapmış olduğu yatırımlar da gözönünde bulundurulduğunda bu sektördeki işlem yoğunluğu önemli boyutlara ulaşmıştır. Ülkemizde temel üretim yapılmadığı için birçok markanın distribütörü bulunmaktadır ve bu distribütörler ana kaynaktan temin, dağıtım, servis, satış sonrası hizmet vb. birçok alt süreci organize etmektedirler.

Yedek parça tedariği de bu süreçlerden en önemlisidir. Ana kaynaktan başlayan ve yurtiçindeki bayii ve diğer firmalar tarafında sonlanan çok yoğun bir tedarik zinciri süreci mevcuttur.

Bu tez çalışmasında ele alınan iki anaproblemden ilki; yedek parça tedarik zincirine dahil olan her lokasyonun kendi bünyesinde farklı yazılım altyapılarını kullanarak stok verilerini tutmasından kaynaklanan veri tutarsızlıkları ve bunun sonucunda oluşan zaman, işgücü ve veri kaybıdır.

İkinci problem ise; sevkiyat hareketleri, stok hareketleri ve lokal stok planlama gibi süreçlerin birbiriyle sürekli haberleşen ve entegre çalışabilen servis yapıları üzerine inşa edilmemesinden dolayı oluşan planlama hataları ve bunun neden olduğu zaman kaybı, para kaybı ve müşteri memnuniyetsizliğidir.

Günümüzde, sektörde bu süreci yürüten distribütör firmaların yapılarını incelediğimizde, belirli kurallara dayanan ve modellenmiş hizmetler bütününün tam olarak bulunmadığını yada farklı noktalarda uygulanan çözümlerin birbiriyle

yeterince senkron çalışamamasından dolayı bu problemlere tam olarak bir çözüm getirilemediği görülmektedir.

Bu tezin amacı, SOA yaklaşımını yukarda bahsedilen iki problemi içeren süreçlere uygulamak ve bu süreçleri servis tabanlı hizmetler mantığı çerçevesinde modellemektir. Tez ile birlikte, sipariş ve stok gibi altsüreçlerin veritabanı ve web servislerini içeren bir uygulaması da gerçekleştirilmiştir.

Sonuç olarak, yedek parça tedarik sektörüne servis odaklı ve modern bir yaklaşım sunuldu. Yeni bir çözüm önerisi ve akademik araştırma literatüre kazandırıldı ve tedarik zinciri yönetimindeki bütün rolleri kapsayan servis odaklı kapsamlı bi çözüm sunuldu. Tüm bunlara ek olarak, mevcut çözümlerin karşılaştırmalarının, anket sonuçlarının ve kavramların önceki ve sonraki değerlerinin karşılaştırmaları ve istatiktiksel değerlendirmeleri de eklendi.

Anahtar Kelimeler: Servis, Yazılım Mimarisi, SOA, XML, Web Servisi, Tedarik Zinciri Yönetimi, Otomotiv Endüstrisi

To My Parents

ACKNOWLEDGMENTS

I express sincere appreciation to my supervisor Instr. Aylin AKÇA OKAN for her guidance and insight throughout the research. Thanks also go to my colleague Bekir ÖZPOZAN is gratefully acknowledged. To my parents, I offer sincere thanks for their continuous support and patience during this period.

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LIST OF ABBREVIATIONS

API	Application Programming
BPEL	Business Process Execution Language
BPM	Business Process Management
DBMS	Database Management Systems
DDL	Data Definition Language
EDI	Electronic Data Interchange
ERP	Enterprise Resource Planning
HTML	Hypertext Markup Language
HTTP	Hypertext Transfer Protocol
SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol
SQL	Structured Query Language
UDDI	Universal Description Discovery and Integration
W3C	World Wide Web Consortium
WS	Web Service
WSA	Web Service Architecture
WSDL	Web Service Definition Language
XML	eXtensibleMarkup Language

1. INTRODUCTION

1.1. Supply Chain Management (SCM)

SCM is the management of materials, information and finances in a process which starts from supplier going through manufacturer, wholesale, retailer and ending with the consumer. SCM involves coordinating and integrating these flows both within and among companies. It is said that providing an affective supply chain management requires reduced inventory (1). SCM integrates key business processes and facilities, involving end users and suppliers that provide products, services, and information.

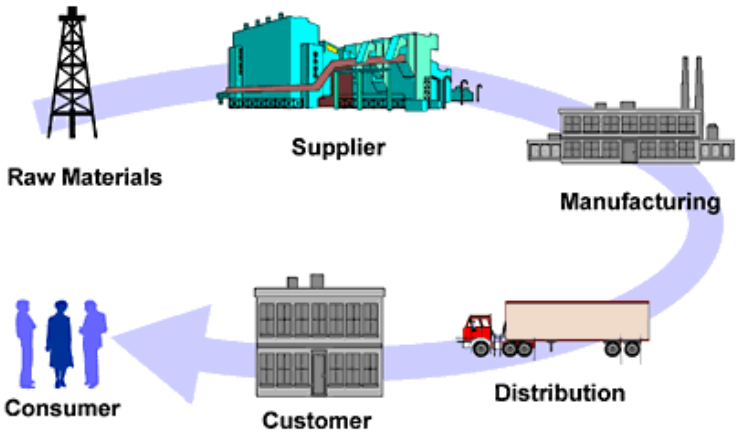


Figure 1: SCM Roles and Flows **(2)**

In an integrated supply chain, information, applications and services are shared among supply chain members and become available for each member. Previous technologies like EDI infrastructures and ERP systems do not support flexible and reusable information sharing and application integration (3).

Supply chain parts such as marketing, distribution, planning, purchasing and manufacturing traditionally operates separately. Supply chain integration helps to reduce cost, improve responsiveness to changes, improves quality level of service and decision making. Members of the integrated supply chain can be able to reach shared information. This enhances supply chain visibility and decrease information delays. Otherwise, insufficient supply chain visibility makes members indefensible to service level problems from business partners and risks (4).

1.2. SCM Problems and Aimed Solution

During the research about SCM for this thesis, it has been found that there are some problems at different levels. The first one is general SCM problems like, production delays, transportation problems and unpredicted errors; they are basically poor planning problems. The second problem that faced with is SOA based SCM solutions lacking points like, industry adaptability, business area support, DBMS platform support, language support and local support. The third and most important problem that observed during field study and acquired from qualified persons who have an active role in SCM. These are data inconsistencies and failure of local stock planning.

In this thesis it is aimed to produce solutions to these above mentioned problems, for the overall scenario we have a central architecture and this structure is service based. This means all data flows, managements and reporting are made from central data via services. This structure provides data and service to all locations inside supply chain. The impact of SOA adoption on performance of SCM is fully mediated through its moderation effect on firm's ability to leverage electronically integrated customers to achieve better electronic supply chain performance. This study presents both research and practice. On the research side SCM and SOA literature completed. On the practice side, a basic sample application is presented.

The rest of the thesis is organized as follows. The next section provides a brief description of Supply Chain Management in Automotive Industry. This is followed by a section Proposed Solution in Chapter 3. Research and Implementation will be explained at Chapter 4. Chapter 5 related with the Results and Evaluation; ın this part the results of the study such as offerings and calculations will be presented. And evaluations that based on these results will be explained. Chapter 6 gives the references and descriptive tables and figures for the data used in the study are provided in the Appendix.

2. SUPPLY CHAIN MANAGEMENT AND AUTOMOTIVE INDUSTRY

2.1. Supply Chain Management Flows

SCM applications have the potential of improving time-to-market of products, reduce costs, and enable all parties in the supply chain to manage current resources better and plan for future needs.

Supply chain management flows can be divided into three main flows:

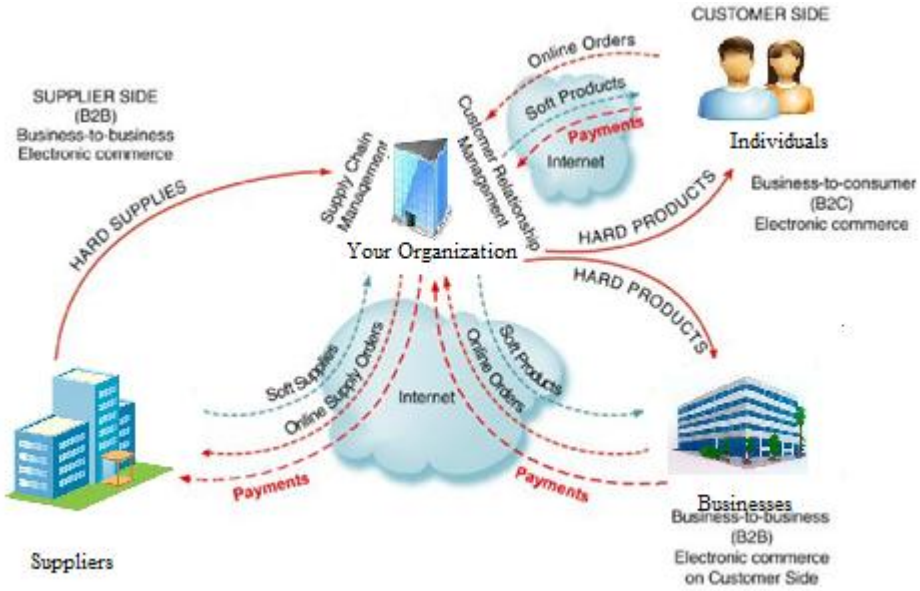


Figure 2: Product, Information and Finance Flow **(3)**

- *The product flow*: The product flow includes the movement of goods from a supplier to a customer, as well as any customer returns or service needs. This flow type is unidirectional. The flow direction starts from supplier and ends at the customer side. This flow includes sub processes like flow of the raw materials from suppliers to retailers, transformation of these raw materials to last products becomes here and delivery flow to the customer begins.

- *The information flow*: The information flow involves transmitting orders and updating the status of delivery. This is a bidirectional flow type. The available data may flow into the end user or from end user to the supplier. For example,

placing orders is a customer to supplier type flow and following up process of these orders is a supplier to customer flow type.

- *The finances flow*: The financial flow consists of credit terms, payment schedules, and consignment and title ownership arrangements. This is the cash flow of the SCM. This flow type is unidirectional like product flow. The difference is the direction of the flow. In financial flow, cash value flows from customer to supplier.

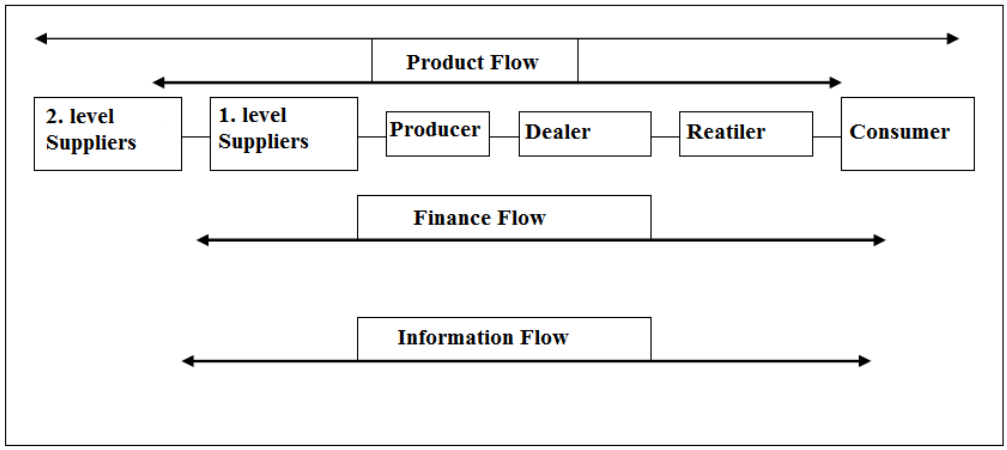


Figure 3: Product, Information and Finance flow **(4)**

2.2. Key Elements of Supply Chain Management

Extended enterprise SCM applications are based information sharing between suppliers, manufacturers and end users. This shared data is recorded in databases or data warehouses. Wide numbers of companies are start using web sites and web-based applications as part of the SCM solution (6).

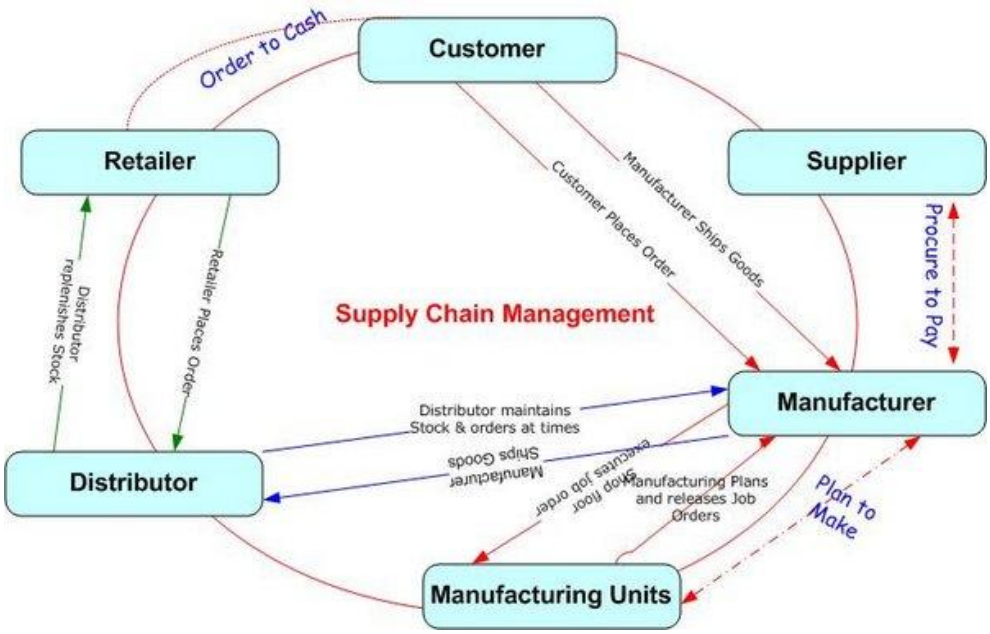


Figure 4: Supply Chain Management Processes **(4)**

Structuring the supply chain requires an understanding of the demand patterns, requirements of service level, and considerations of distance, cost elements and other related factors. These variables need to be considered during supply chain analysis process.

There are six key elements to a supply chain (30):

- Production
- Supply
- Inventory
- Location
- Transportation, and
- Information

2.2.1. Production

Strategic decisions regarding production focus on what are the customer needs and the market demands. This first stage in developing supply chain agility takes consideration what products and how many products to produce. The strategic

decisions for productions must also focus on capacity, quality and volume of goods, for meeting customer demand and satisfaction. Operational decisions; scheduling workloads, maintenance of equipment and meeting immediate market demands should be done with the consideration of quality control and workload balancing.

2.2.2. Supply

An organization must determine what are their facilities or facilities to produce, both economically and efficiently. Outsourcing is an excellent alternative for organizations which cannot produce products and components effectively. Companies must carefully select suppliers for raw materials. For choosing a supplier, companies should focus on developing velocity of supplier, quality and flexibility. This features reducing costs and maintaining low cost levels.

2.2.3. Inventory

Further strategic decisions focus on inventory and how much product should be stocked. This is a critical issue for an effective supply chain management. Operational inventory decisions revolved around optimal level of stock at each location to ensure customer satisfaction.

2.2.4. Location

Location decisions depend on market demands and determination of customer satisfaction. Strategic decisions must focus on the placement of production plants, distribution and stocking facilities, and placing them in prime locations to the market served.

2.2.5. Transportation

Strategic transportation decisions are closely related to inventory decisions as well as meeting customer demands. Using air transport obviously gets the product out quicker and to the customer expediently, but the costs are high as opposed to shipping by boat or rail.

2.2.6. Information

Effective supply chain management requires effective information sharing system, linking information resources throughout the chain for speed of exchange. In today's competitive world overwhelming paper flow and disparate computer systems are unacceptable. Linking computers through networks and the internet, account management software, product configurations, resource planning systems, global communications are the key components of an effective supply chain management system.

2.3. Supply Chain Management Components

The SCM components and services are mentioned in detail in the first section. These are order management, logistics and warehouse (stock management) processes. By the help of these services which operation can be done is introduced in detail. The first one is order management.

- *Order Management:* Order Management Services has become a widely used term in today's supply chain schedules. OMS is used for a number of business services like telecoms, retail, health care, finance and automotive industries in order to keep a track of customers, accounts, credit verification, product delivery, billing, etc. An ideal service based OMS uses services as data providers and serves data in a common format by services. This makes it useful for identifying immediate opportunities for improvement.

  The advantages of Order management in our solution services are many to mention:

  - Maintenance of a competitive edge made possible.
  - It helps to reduce order management costs.
  - Profitability is ensured while adapting to the customer demands.
  - It helps in increasing the order profitability.
  - Increase in the productivity and quality due to standardization of processes.
  - Provides end to end seamless integration among all relevant processes throughout the enterprise.

- Involves collaboration and process integration with customers, distribution and suppliers including contract manufactures, transportation carriers and distribution centers.

- *Logistic Management:* There are important points to manage and pursue the logistic process. These are communication with logistic firms, making right route plan, minimize shipping movements, minimize harm and loss during transportation and sustain the process more efficiently.

  Logistics processes in automotive industry work as the same. This means there is an accepted treatment generally. This can be summarized as making agreements with the logistics firms that have vehicle filo and demanding vehicle from these firms before shipments. In presented solution there is no different offering from this system. Instead of this there will be some steps that can be integrated to existing system for improving it. The aim is to improve and make more efficient these sub processes.

  Presented solution has a central structure and modular. This features become important at that point. Because it has a central structure it can give instant data correctly by querying the services. Modularity keeps data meaningful if some parts of data will remove. If spare part code removed from the vendors total orders information can give the information about quantity. If this data is filtered according to the specific date intervals, the data of product quantity of shipment will be shown. Sharing this data with other logistic firms inside the network will help to planning probable shipments.

  Total number of orders that will be shipped for city based or region based can be presented by additional service structures within same infrastructure. In addition, by giving past time intervals order shipment movements and quantities can be find. The services related with order and logistics can communicate with each other and this makes easier and correctly planning logistics.

- *Warehouse Management:* Warehouse management is an important process of SCM. Planning ware house correctly means that making location in a more efficiently. This provides warehouse processes become faster. The presented

solution provides 2 benefits. First one is distributor based and the second is vendor based. As mentioned at the previous part of the thesis, distributor has virtual vendors inside its own depot areas according to the shipment regions. Before making shipment, sends parts collected in the depot area and stored to the virtual places. This process helps saving time.

Order quantities of vendors from different locations of country can differ according to season, special time, in winter or before summer holiday, etc. According to these periods vendors total orders can be queried with services. By means of this how many shipping for which vendor group, in which period questions can be answered and planning in distributor side making according to this. So, making plan according to the data coming from services saving time and labor.

Vendor side situation is the same. Vendors can take advantage of services while making their local depot location. Queried services from vendor's side are selling services not order services. Mostly selling spare parts are located appropriate places inside the depot areas according to specific periods.

2.4. Automotive Industry

Automotive industry has one of the most complex supply chain mainly because of the complicated nature of the end product, number of supply chain partners involved and the geographical locations of supply chain partners. A typical vehicle requires around 5.000 – 7.000 finished parts; and these finished parts in turn consume nearly 130.000 subparts (5). These parts are either manufactured in-house or sourced from multiple supply chain partners across the world.

In the automotive industry, there are many attempts to develop methodologies, standards, and technologies to integrate many applications for product design and manufacturing. However, there is a lack on integrating and aligning product design and manufacturing with other operations in supply (6).

In dynamic and competitive environment, a superior supply chain is a critical and important element for differentiating automakers from others. In fact, many of trends

in the automotive industry are reinforcing the need to redefine supply chain strategies, layouts, and operations.

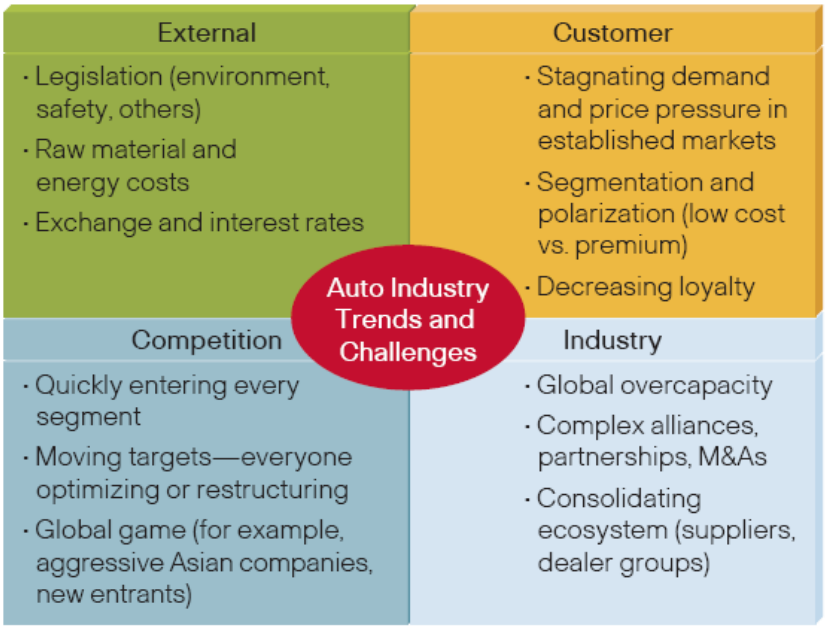


Figure 5: Auto Industry Trends and Challenges **(6)**

The increasing requirement for real-time information and effective communication across the supply chain network is critical for managing and optimizing the supply chain, while keeping costs under control (6).

Supply chain in automotive industry is a bit different from other industries and sectors. The differentiation is; in automotive industry supply chain is generally based on one brand, but in an e-commerce system there can be many brands from many suppliers. Retailers work with different suppliers for different kinds of products from same brand or different brands. But in automotive industry there is one supplier, one distributor and many vendors, all parts of this supply chain have to work with specific brand. Vendors have to communicate with only one distributor and this distributor has to deal with only one supplier.

The other point in automotive industry supply chain is the cost tolerance. It is important to plan and manage the product flow of spare parts because their costs much higher than an e-commerce products. Mistakes made in product flow organization causes big losses and it affects the economy also.

2.5. Problems in Automotive Industry and Solutions

As known, the research subject of this thesis is the automobile industry which owns an intensive data flow. Especially the supply chain schedule is the leading fundamental process. Normally, this data density causes several problems. These problems are associated with order process, logistic operations, data acquisition operations or other parts. It is not a right matter to say there are no solutions to solve these problems. Therefore, up to now lots of solution enterprise actualized.

When the existing solutions are examined carefully, it is seen that these solutions usually intended on only one circle of the supply chain or focuses only a local region of the problems. Of course it does not mean that solution studies are unsuccessful or they do not return positive results. But it is true that these solutions partially insufficient sometimes at some situations.

For example, in the study of Background Note on Supply Chain management in Automotive Industry Auto SCM India 2006, Chennai (7) handles growing of their own country's spare part manufacturing industry against their automobile manufacturing sector. So they are nested industries. And they examined the subject in that respect. Similarly another study on supply chain management problems at South African automotive component manufacturers, M. J. Naude & J. A. Badenhorst-Weiss (8) interested on the problems of the supply chain problems of African continent. They handle the problem from a different respect. They mention about logistic problems of the supply chain schedule.

In view of the diverse business activities, today’s supply chain process is very critical for success in current business scenario. Today, the supply chain managers are facing various external challenges driven by customer requirements and intense competition. The major challenges (7):

- Network Planning – This is one of the most important issues for SCM. Determination of production requirements and inventory levels at the vendor’s facility for each product and development of transportation flows between these facilities to the warehouses in a best possible way to reduce total production, invent and transportation costs with fulfillment of service level requirements.

- Supply Chain Integration and Strategic Partnering – In SCM, information sharing and operational planning are crucial for successfully integrated supply chain. But the challenges are – what type of information would be shared, and how this information will be used, what level of integration is required and what partnership can be implemented.
- IT and Decision Support System– This is another important challenge for SCM. Today, SCM is driven by the scope and opportunities appearing due to abundance of data and the savings which can be achieved through efficient analysis of these data. What data should be transferred with its significance and most importantly, what infrastructure is required internally and between its partners is very important.
- Training – It is important for every company, which is implementing SCM. Companies must leverage extensive training to their employees, who are going to use the system. Understanding the market, risk, and expenditure analysis and applying strategic sourcing methodologies are important.

The automotive supply chain is one of the most complex organizational structures in operation today.

By their nature, requests for emergency delivery services are normally caused by unusual or unexpected situations. Evolution Time Critical's survey data reveals, however, that those hundreds of different issues can be grouped into five basic types:

- *Production delays:* All quality level problems rework, equipment problems, delays in the material supply can result in late production time than expected.
- *Human error:* Cars are complex machines built from thousands of separate parts. It is possible the wrong part can be requested, or the right part requested but the wrong one supplied, or for problems with data entry leading to the wrong part numbers, or the wrong number of the right parts arriving at the factory gate.
- *Transportation problems:* Vehicle breakdowns, customs delays, bad weather or other delays can all result in the conventional supply chain failing to meet delivery schedules.
- *Unpredicted demand*: Despite their best efforts to manage demand, car and component makers can be caught out by the unexpected popularity of particular models or vehicle configurations.

- *Planned high-speed delivery*: In an emerging number of cases, car makers are using high speed delivery as a core part of their supply chain.

Production delays were the most important cause of emergent delivery requests according to the surveys, accounting for 28% of emergency shipments. Human error was the second major cause accounting for 15% of shipments. The third one is unpredicted demand, and then transportation problems come. Planned critical deliveries come at final with 7% of the European shipments analyzed (7).

2.6. Background and Existing Solutions

As to mention about major players in the industry, DaimlerChrysler uses e-mail, EDI, Supply Partner Information Network (SPIN) and Electronic Funds Transfer (EFT) to contact with its suppliers. EDI describes itself as the standard for communication between partner systems. All these e-commerce transactional methods can be integrated into ANX. DaimlerChrysler has identified ANX as the basic communication platform for its Extended Enterprise strategy (16).

ANX is a web-based network infrastructure designed to improve communication between automotive business partners. It is less complex and expensive than the systems in use and more reliable than the public internet (16).

DaimlerChrysler, Ford and General Motors view this technology as a preferred method for future automotive business. There is only network link required for conducting commerce electronically within the automotive industry. From the side of manufacturers, ANX is an accessible platform for suppliers and customers (16).

Web-based portals are common in the automotive industry, and can be used as commerce and communications platforms. On the one hand, there are specialized portals provided by manufacturers for their suppliers (11).

At VW (group procurement volume € 60 billion p.a.), 5,500 suppliers are now linked in to the supplier platform. At Daimler, order placement by electronic catalogs is one of the basic initiatives in supply (11).

Customer details are already held by dealers, and so many manufacturers have tried to implement Dealer Management systems (DMS) which are integrated with the ordering systems. This has proved to be far from easy, because of the implementation costs and above because of the efforts for the dealers to preserve their independence and retain ownership of their customer details. Some independent dealers also have contracts with several manufacturers and would need to deploy multiple DMS systems (11).

Requirements to support different data format across multiple applications that communicate using different protocols and are deployed in disparate systems poses considerable challenge in integration of collaborative supply chain:

- Supporting multiple data formats (e.g., EDI, flat file, etc) both within enterprise and external to enterprise (supply chain partners)
- Exposing business interfaces locked in supply chain applications as services using standards based syntax (e.g., WSDL)
- Supporting multiple types of end points e.g., JMS, HTTP, .NET, EJB, RMI, databases, etc.
- Support for widely adopted standards for business document interchange e.g., RFC4130 for MIME-based HTTP EDIINT transfers (use for EDI) and STAR specification for Business Object Documents (XML) transfer using ebXML and web services
- Defining common business schema, that maps to different application specific schemas and required transformations
- Providing means to create process from services using workflow languages like BPEL etc.
- Manage authentication and authorization across multiple business domains
- Integration of supply chains with least cost and minimal effort.

2.7. Comparison of Related Solutions

In this section of thesis comparison of the existing COTS (Commercial Off The Shelf) solutions will be detailed. This comparison is made between the existing SCM solutions and parameters that are used in comparison determined by the proposed method.

For the comparison the web based infrastructure tool; Technology Evaluation Center (TEC; http://scm.technologyevaluation.com) is used. This infrastructure takes some answers from users according to their systems. Then, analyzing these answers according to the existing solution requirements. The screenshots of questions are given in appendix. The result is presented with graphs this helps users to understand the differences between these solutions.

In Table 1 the data which is based on the proposed solution in this thesis are given in first column. Following fifth column shows the situation of SCM solutions according to the responses. These responses are given according to one of the leading distributor firm in Turkey and its specified vendor.

The responses given based on thesis scenario, are business area, financial volume, budget, functionality, availability to sector, employee number in SCM network, server platform parameters. These parameters are determined by the comparison tool of Technology Evaluation Center (TEC). The details of these parameters are given in section 2.7.1.

As seen in Table 1, the SCM solution results are shown according to the evaluation criteria. It is seen that compared solutions inadequate or not working in full performance in some situations (“not a competence" and “some or adequate support”). If it is evaluated in general, the solutions which are based on substantial background and successful are belong to rooted big companies. But, when the requirements and scenarios become specific each of them has some less successful points.

Table 1: Comparison Details of SCM Solutions **(9)**

	Your Responses	Prophet 21 By Epicor	Dynamics NAV By Microsoft	JD Edwards EnterpriseOne By Oracle	SAP Business ByDesign By SAP	Bluebee By Bluebee Software
1	**Annual Revenue**					
1.1	$10 to $50 million	Yes or Extensive Support	Yes or Extensive Support	Yes or Extensive Support	Yes or Extensive Support	Yes or Extensive Support
2	**Budget**					
2.1	More than $1,000,000	Yes or Extensive Support	Yes or Extensive Support	Yes or Extensive Support	No, Not a Competence	Yes or Extensive Support
3	**Business Area**					
3.1	Customer Service	Yes or Extensive Support	Yes or Extensive Support		Yes or Extensive Support	Yes or Extensive Support
3.2	Logistics	Some or Adequate Support	Yes or Extensive Support		Yes or Extensive Support	Yes or Extensive Support
3.3	Maintenance	Yes or Extensive Support	Yes or Extensive Support		No, Not a Competence	Some or Adequate Support
3.4	Planning	Yes or Extensive Support	Yes or Extensive Support		Yes or Extensive Support	Yes or Extensive Support
3.5	Purchasing	Yes or Extensive Support	Yes or Extensive Support		Yes or Extensive Support	Yes or Extensive Support
3.6	Sales	Yes or Extensive Support	Yes or Extensive Support		Yes or Extensive Support	Yes or Extensive Support
3.7	Warehouse or Inventory Control	Yes or Extensive Support	Yes or Extensive Support		Yes or Extensive Support	Yes or Extensive Support
4	**Customization, Thin-client Access, and Standards (question skipped)**					
5	**DBMS Platform**					
5.1	Microsoft SQL Server	Yes or Extensive Support	Yes or Extensive Support	Yes or Extensive Support	Yes or Extensive Support	Yes or Extensive Support
5.2	Oracle	No, Not a Competence	No, Not a Competence	Yes or Extensive Support	Yes or Extensive Support	Yes or Extensive Support
6	**Functionality by Business Area**					
6.1	Customer service and support	Yes or Extensive Support	Yes or Extensive Support	No, Not a Competence	Yes or Extensive Support	Yes or Extensive Support
6.2	Logistics and distribution management	Yes or Extensive Support	Yes or Extensive Support		Yes or Extensive Support	Yes or Extensive Support
6.3	Order management	Yes or Extensive Support	Yes or Extensive Support		Yes or Extensive Support	Yes or Extensive Support
6.4	Production planning	Yes or Extensive Support	Yes or Extensive Support		Yes or Extensive Support	Yes or Extensive Support
6.5	Purchasing management	Yes or Extensive Support	Yes or Extensive Support	Yes or Extensive Support	Yes or Extensive Support	Yes or Extensive Support
7	**Industry**					
7.1	Motor Vehicles	Yes or Extensive Support	No, Not a Competence	Yes or Extensive Support	Yes or Extensive Support	Yes or Extensive Support
8	**Language Support**					
8.1	English	Yes or Extensive Support	Yes or Extensive Support	Yes or Extensive Support	Yes or Extensive Support	Yes or Extensive Support
8.2	German	No, Not a Competence	Yes or Extensive Support	Yes or Extensive Support	Yes or Extensive Support	No, Not a Competence
9	**Local Support**					
9.1	Europe (east and south)	No, Not a Competence	Yes or Extensive Support	Yes or Extensive Support	No, Not a Competence	Yes or Extensive Support
9.2	Europe (west and north, including the United Kingdom)	Some or Adequate Support	Yes or Extensive Support	Yes or Extensive Support	Yes or Extensive Support	Yes or Extensive Support
10	**Motor Vehicles**					
10.1	Wholesale and Retail Trade	Yes or Extensive Support	No, Not a Competence	Yes or Extensive Support	Yes or Extensive Support	Yes or Extensive Support
11	**Number of Employees**					
11.1	51 to 100 Employees	Yes or Extensive Support	Yes or Extensive Support		Yes or Extensive Support	Yes or Extensive Support
12	**Outsourcing Services (question skipped)**					
13	**Server Platform**					
13.1	Microsoft server (such as Windows NT/2003/Vista)	Yes or Extensive Support	Yes or Extensive Support	Yes or Extensive Support	Yes or Extensive Support	Yes or Extensive Support

When the Table 1 is examined, it can be seen that, some lacking parameters are at top level and some of them at reasonable levels. For example, the basic evaluation on Microsoft solution DynamicsNav is inadequate in automotive vehicle sector which is the main topic of this thesis. The reason for this related solution is based on

manufacturing. Before testing the answer Sales & AfterSales choice has been chosen regarding to Manufacturing, because Sales & AfterSales subject is more suitable to our scenario. It is useful to recall that the presented solution in this thesis focuses on spare part supply process.

The other important point is, other solutions support MicrosoftSQL Server as a database management system but Oracle does not. The solution proposed has the database background with SQL Server, so it can easily said that there is an advantage presented to integrate with external solutions.

It is seen that logistic and maintenance processes are not supported by some solutions however they already exist in the proposed solution as a process support in this thesis project. Logistics is an important process because this thesis handles SCM processes. Anyway, it is mentioned that the services will be shared with logistics firms and by the help of sharing this information logistic planning will become more productive. Also, for decreasing costs, the importance of minimizing shipping movements is mentioned.

Similarly, the schedules that are related with maintenance are also important. Because when it is evaluated as maintenance of motor vehicles, it is seen that schedule starts with maintenance process. The first need of spare parts appears at this stage.

Language and local support issues are included in the adequate points. Language compatibility and local support are important parameters for an efficient study. Lack of local support causes increase of costs; and in the situations like the system needs short term technical interventions, it may cause disruption and delay of processes.

At this point it is possible to mention that the study that proposed may be a basis of a language compatible, regional supportable and robust solution as the competitor software infrastructures included in the comparison. It will be a positive development in the term of not only continuation costs but also supporting all sub processes that, usage of a completely SOA-based SCM solution that intended needs of the scenario and architected on the model suggested of the distributors which are situated in Turkey.

Related graphical data is shown in the Figure 6.

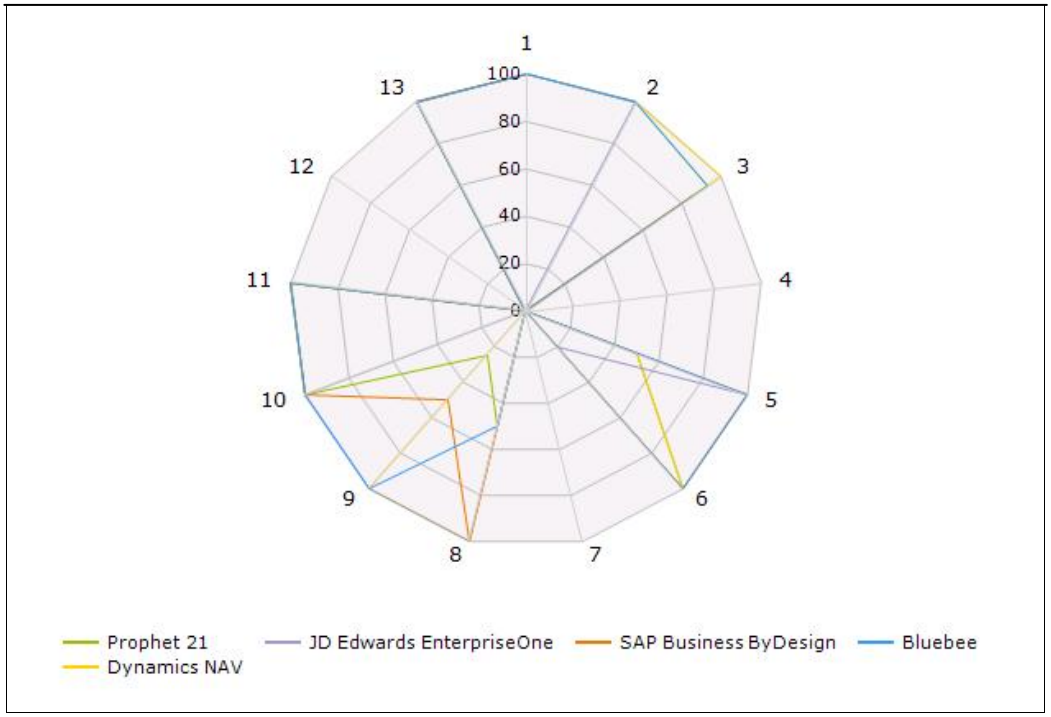


Figure 6: Relative Strengths & Weaknesses of Solutions **(9)**

The graph provides an overview of the relative strengths and weaknesses of the selected products, based on user's answers to the questionnaire. The numbers along the outside of the graph correspond to the question numbers. The numbers down the middle (0, 20, 40, 60, 80, 100) represent the product's ability to meet user's needs, expressed as a percentage (9).

General evaluation results are shown in detail in the Figure 7. According to the parameters related with the thesis scenario, the most efficient solution is Blubee SCM solution.

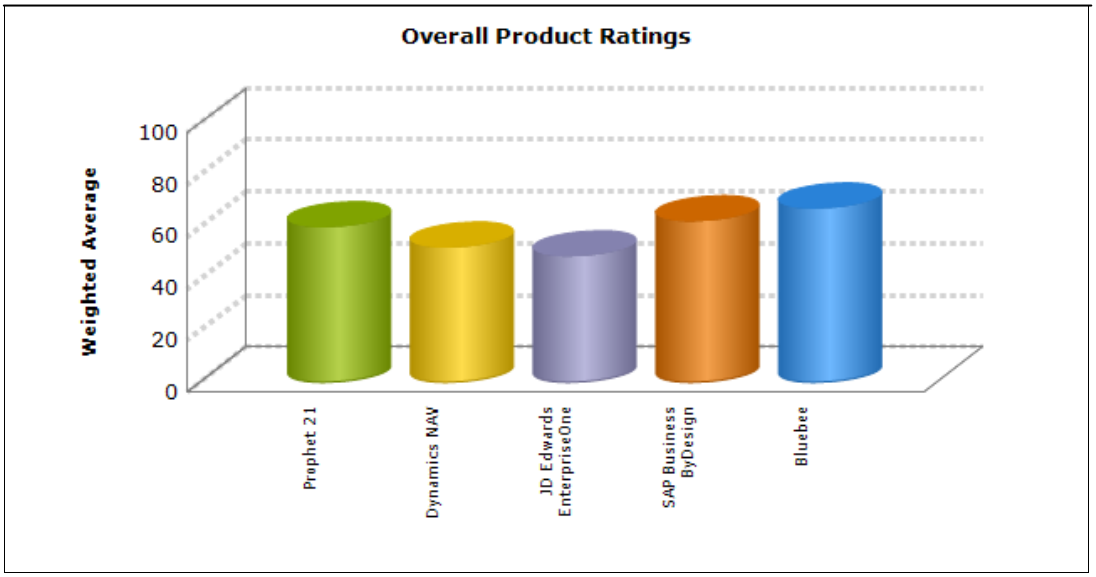


Figure 7: Overall Product Ratings **(9)**

The chart in Figure 7 is based on a comparison of the answers provided against our selected products' functionalities, and shows the overall ratings.

Rank		Product/Vendor	BestMatch Factor (BMF)	Weighted Average (WA)
1		Dynamics NAV (Microsoft)	78.40	82.15
2		Prophet 21 (Epicor)	40.14	57.37
3		Bluebee (Bluebee Software)	3.84	15.85

Figure 8: In-depth Analysis of SCM products **(9)**

With the help of this study, the solutions existing in the market are compared for the convenience to presented solution and meet the requirements. In the Figure 8 the lacking and inadequate situations are shown.

2.7.1. Criticism & Evaluation of Presented Approach

The most appropriate approach to be presented in this section is, making a detailed review on missing or inadequate points of other compared solutions. Importance of these parameters in a SOA based SCM solution will become more clear after this parameters and specifications have been explained deeply. However, disadvantages created by these situations will be mentioned. Immediately after, viewpoint for these situations of presented approach, suggested solution and advantages of our approach will be presented.

Firstly, “suitability for automotive sector” subject may be considered. As mentioned before many times, the rapid development of the automotive industry in our country, causes increased data density. By the parallel development of software technologies and the automotive sector, need to follow the more process in more detail have been appeared. Therefore, it is a requirement to include special situations also for SCM process of automotive industry. It can be seen that, some of the compared solutions support automotive (motor vehicles) industry and some of them are not. But none of these approaches has been developed for directly suitable for automotive sector.

At this point, an important advantage of presented approach appears. Because of the handled subject is a specific process as "supply chain process of automotive industry", it will be possible to mention about a detailed following and managing advantage. During the analyzing process, functioning and problems of this sector has been considered and the main services that build the basis of SOA approach are planned on this analysis. However this “specific planned for automotive industry” situation provides presented approach re-applicable and resellable. And this situation means an important contribution to national economy.

Another main topic which examined at the comparison table is Business Area. It can be seen this topic includes some main processes as customer service, logistics, maintenance, planning, sales and purchasing. Each of these processes has an important place at the industry that has been considered and following these processes is important. It can be seen that some approaches do not support logistics and maintenance processes. Because, the main control start after product entrance at some industries, but not in automotive industry. Logistic process is very important at

considered process (SCM of automotive industry) as mentioned in our scenario, and there is a continuously multidirectional action between distributor and vendors network. So it is necessary to control this logistics process and its effects on complete process.

The presented approach is advantageous because it considers the logistics process of automotive industry and includes the sub processes of logistics to the solution plan. A similar situation also applies to maintenance and repair process.

A need to focus on other two parameters are; language and regional support. There will not be an extra cost problem which causes by language support situation. Also, presented approach has an important advantage about continuously support and system maintenance because of the purpose of developing and creating basis of a SOA based SCM solution for our country. The presented approach is more flexible on the situations as rapid responses (at necessary situations), dependency, system interruption based loses and cost of maintenance and support process.

3. PROPOSED SOLUTION

During the literature research, the studies that discourse all the members of chain but presents a superficial solution may also be referred. Namely, some weak software solutions may be example for these situations. The software system that only the member of supply chain may enter data and list/filter them is not a competence solution. The software systems must be reachable, flexible, distributed and unique centered. Also must be protocol independent, service oriented and modeled correctly for all steps of the schedule. The need of SOA based structures comes into prominence at this point.

The solution suggested in this study is SOA based. The advantages of the SOA strategy will be mentioned in the coming sections. Thereby, it is not wrong to say that advantages will be valid for the solution proposed. The SOA based solution here firstly models all processes correctly, determines the real- roles of the scenario, states all work routines for all these roles. After this, the solution models all processes as services.

SOA enables all sub schedules realizable step by step and connects sub processes of all members to this backbone architecture. This means that the services communicate and operate in chain of rules. This working principle provides saving time, labor and costs.

3.1. SOA Strategy

An architectural paradigm SOA is used for organizing and utilizing capabilities or services. Different ownership domains take control of distributed services. A main goal of SOA is to provide that capabilities or services in different ownership domains to be reused and shared effectively (10).

SOA separates functions into distinct units like services. These services can be shared over a network and can be reused and combined to create business applications and they can be communicate with each other by passing data to each other, or coordinating an activity between more than one services. SOA enables applications to use services available in a network such as the World Wide Web (11).

In other words, a SOA is a way of sharing functions in a widespread and flexible way. In order to decrease the problems of heterogeneity, interoperability and ever changing requirements, such architecture should provide a platform for building application services. SOA presents an approach for building distributed systems that deliver application functionality as services to either end user applications or other services (12)

3.1.1. SOA Characteristics and Architecture

SOA is an architectural paradigm that aimed to achieve loose coupling through interacting software services. A service is a part of work that is done by service provider to reach the desired end results for service consumer (13).

Service oriented architecture is an approach which has its own unique policies and has been implemented in different industries. It needs to have detailed analysis and modeling to design well-defined services (14).

Service oriented architecture has the following characteristics:

- Services are self-contained and modular
- Services support interoperability
- Services are loosely coupled
- Services are location transparent
- Services are composite modules, comprised components.

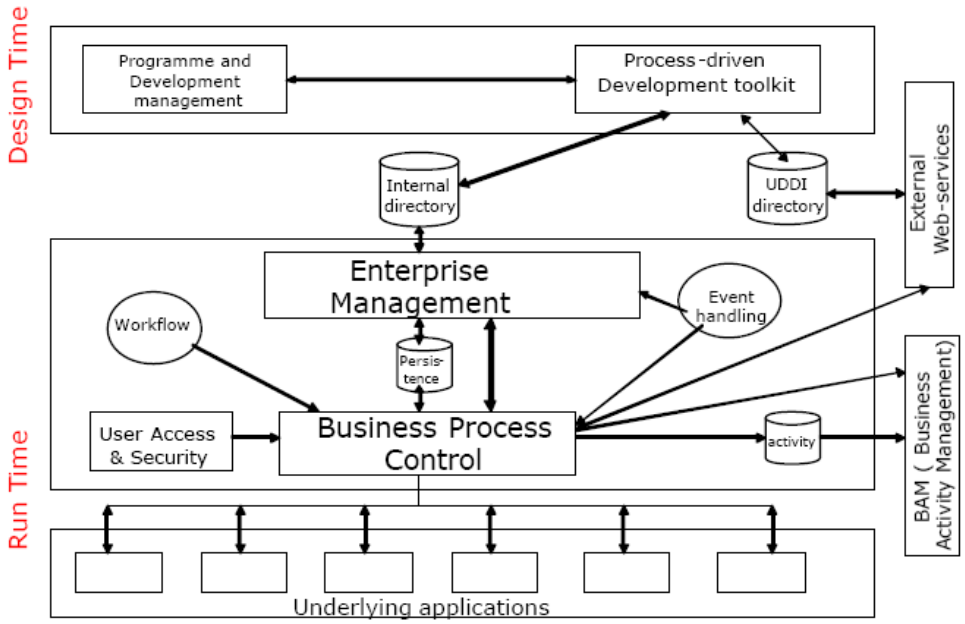


Figure 9: SOA Architecture **(15)**

"*Service-Oriented Architecture (SOA) is an architectural style for creating an enterprise IT architecture that exploits the principles of service-orientation to achieve a tighter relationship between the business and the information systems that support the business*." (16)

3.1.1.1. Enterprise Service Bus (ESB)

To run a SOA in practice a way of calling services is needed. This infrastructure is the technical backbone of the SOA landscape. It is the responsibility of the ESB to enable consumers to call the services. Depending on the technical and organizational approaches taken to implementing the ESB, this responsibility may involve the following tasks;

- Providing connectivity
- Data transformation
- Intelligent routing
- Dealing with security
- Dealing with reliability
- Service management
- Monitoring and logging

The ESB's main role is to provide interoperability. Because it integrates different platforms and programming languages, a fundamental part of this role is data transformation (16).

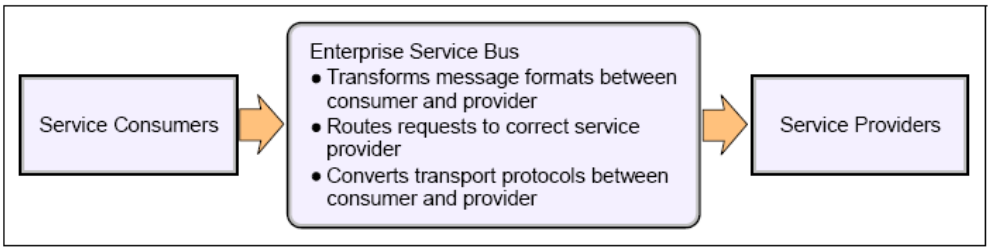


Figure 10: Enterprise Service Bus **(17)**

The Enterprise Service Bus concept is an architectural practice for implementing a Service Oriented Architecture. As shown in the Figure 10, establishes an enterprise-class messaging bus that combines messaging infrastructure with message transformation and content-based routing in a layer of integration logic between service consumers and providers.

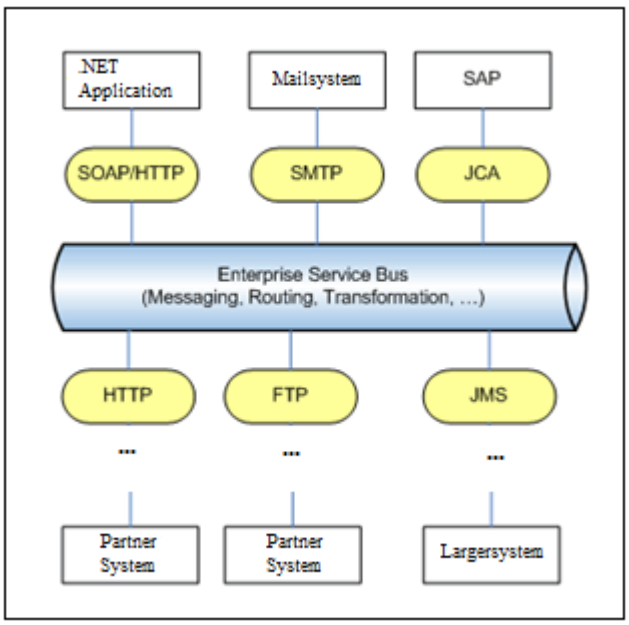


Figure 11: Enterprise Service Bus Detail **(17)**

The main aim of the Enterprise Service Bus is to provide virtualization of the enterprise resources, allowing the business logic of the enterprise to be developed and managed independently of the infrastructure, network, and provision of those business services. Resources in the ESB are modeled as services that offer one or more business operations.

3.1.1.2. Service

A service is a part of self-contained business functionality. This functionality may be simple like storing or retrieving customer data or become complex like a business process for customer's order (17).

3.1.1.2.1. Service Consumer

The service consumer is an application, a software module or another service that requires a service. It is the entity that initiates the locating of the service in the registry, binding to the service over a transport, and executing the service function. The service consumer executes the service by sending it a request formatted according to the contract (13).

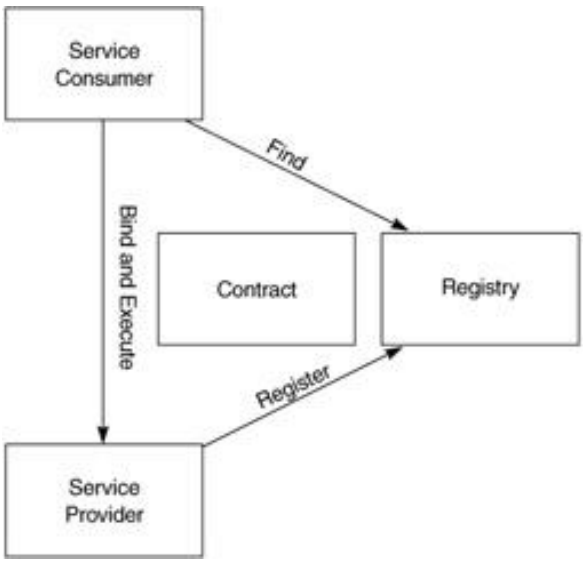


Figure 12: SOA Components **(13)**

3.1.1.2.2. Service Provider

Service provider is a network addressable entity that accepts and executes requests from consumers. It can be a mainframe system, a component, or some other type of software system that executes the service request. The service provider publishes its contract in the registry for access by service consumers (13).

3.1.1.2.3. Service Registry

A service registry is a network-based directory that contains available services. It is an entity that accepts and stores contracts from service providers and provides those contracts to interested service consumers (13).

3.1.2. Microsoft SOA Infrastructure

In the sample application of presented approach, Microsoft technologies Visual Studio.NET (as development platform) and SQLServer 2008 (as database server) are used. The reason of the choice of Visual Studio as a developing platform, capable of offering a service-oriented development environment according to business needs. Just another important feature was programming language independence.

Also the most appropriate database platform for used technologies is SQLServer 2008. Already this database engine is also a product of Microsoft. The most efficient, performance and stable database engine for an application which has been developed on Microsoft Visual Studio is Microsoft SQLServer.

The Microsoft Services Service Oriented Architecture Infrastructure solution provides the agility organizations require by adding coordination, visibility, and manageability of services to the benefits of interoperability through service virtualization. With service virtualization it is possible to apply different service facades and policies to your data and logic to provide the right service for the right scenario.

While dynamically exposing and brokering services, the service oriented architecture infrastructure solution can also use a common infrastructure to provide the visibility and manageability necessary to make massively distributed systems successful in the

enterprise. Through this virtualization approach, SOA infrastructure solution can help your organization deploys services faster, embrace chances as they occur, and maximize the reuse of systems and infrastructure components (18).

Microsoft Services Service Oriented Architecture Infrastructure provides

- Reduced time-to-market for new services
- Advance service versioning
- Service policy enforcement
- Service enablement of legacy systems

Built up on the Microsoft server platform(which includes the Windows 2008 OS, Microsoft SQL Server 2008 Database SW, and Microsoft .NET Framework 4.x), it takes full advantage of the capabilities in the underlying infrastructure to provide a reliable scalable platform on which an organization can build its SOA system in heterogeneous environments (18).

The SOA infrastructure solution can also take advantage of Microsoft BizTalk Server 2009 to provide additional capabilities for your SOA such as business activity monitoring (BAM) for end-to-end visibility, business rules engine (BRE) for dynamic policies, host systems integration for service assisting legacy systems, and Enterprise Service Bus Tool Kit 2.0 (ESB) for durable message routing (18).

3.2. SOA and SCM

Supply Chain Management is not a new thing, over the past 10 years; companies have spent money and time to make sure that their supply chains are efficient. They try to find a solution to automate the supply chain, building electronic relationships with business partners and suppliers also finding the areas where time, costs, or waste could be reduced.

New business models have appeared with the Internet, the World Wide Web, and related technologies, like Service Oriented Architecture (SOA) and web services.

Today business environment is more competitive than before; changes in customer demands, financial pressures, and changes in technology and government regulations

are continuous. Thus, companies are trying to find more flexible and adaptive ways to compete in this economic environment. Supply chains are profoundly challenged by this new environment.

In a supply chain products or services moves from supplier to the end user. Suppliers provide row materials or services, manufacturers combine these row materials and produce products, warehouses stores raw materials and manufactured products, distributors provide finished products or services, and customers purchase them. The main goal of the supply chain management is to achieve efficient use of resources to meet customer demands.

Proposed solution is based on the Service Oriented Architecture, uses web services to achieve an automated supply chain management. By the use of SOA, proposed solution ensures that the differently enterprise IT systems can quickly and easily adapt to rapidly changing business needs.

Applying SOA structure to supply chain management, presented approach aims to eliminate or decrease human intervention, thus, reduces costs and supply chains become more efficient.

3.3. SOA in Automotive Industry

In the automotive industry, some companies are pursuing a clear strategy for their non-competitive processes with a standardized software architecture, which means a largely closed system. This centralization and redundancy avoidance aimed to produce cost benefits. On the other hand, SOA approach is very individual, open and flexible. SOA can achieve the same cost benefits at the same time with many other advantages.

The selected five key features below (19) describe the commercial potential of SOA, which make up the general, benefit case for SOA and which may be of great relevance for the automotive core processes and for a decision for or against service-orientation:

- *Reusability*: It is obvious that any copying and duplication of the same information, for whatever purpose, is an unproductive activity which should be

avoided. It makes no sense to store information on the same workflow or process in several places or in multiple applications. Each piece of information should be held uniquely and in one place. With a service to store the relevant data in a central location and make it available for retrieval by any authorized user, applications could then be made leaner in development and cheaper to operate. Furthermore, consequential costs caused by redundancy, such as consistency checks on data from different sources, can be reduced with SOA.

- *Flexibility*:

  Production flexibility: Ability to manufacture a product in different value-creation systems

  Product flexibility: Ability to make more than one product in the same system (e.g. different models of car on one assembly line).

  Variant flexibility: The ability to produce multiple variants.

  Volume flexibility: Ability to manufacture different quantities of a product, without substantially changing the unit costs.

  Location flexibility/mobility: Ability to produce and deliver quickly from other locations.

- *Agility:* SOA provides an opportunity to improve agility, in that only individual services need to be modified or additional services "purchased" ready to run, so the necessary process changes can be put in place very quickly. New services can then be introduced faster and existing services can be more easily (and quickly) adapted to meet new requirements.
- *Availability:* The IT infrastructure needs to work round the clock. Tough penalties are accordingly negotiated with IT service providers, which kick in when the agreed availability levels are not achieved. A decisive factor in this regard is the ease of maintenance of the systems. The better this is, the better the overall availability will be. As a rule, clear and simple architectures with a small number of standardized interfaces result in great ease of maintenance. A

generally encapsulated and service-oriented architecture can therefore do justice to the issue of availability to a very large extent.

- *Collaboration:* Connections are therefore needed between business processes, technologies and people, going far beyond the current level of collaboration between automotive manufacturers, their suppliers, dealers and importers. An SOA-based Enterprise Architecture – with standardized services and interfaces, which can then be used across operations – offers optimum support, as it grows alongside the emerging networks and the changes to them.

Figure 13: Relationship between SOA Phases and Economic Potential (29)

SOA has the potential to realize economic potential in the automotive distribution sector through IS standardization. Furthermore, it is currently impossible to establish a single information system for all players' involved in automotive distribution. This is due to the dynamic environment with its frequent changes with regard to the layout, content and functionality of the corresponding IS - especially web-based systems - as well as to political and power aspects. Value can be created by introducing SOA.

Integrating the respective external partners is also important. This business impact is connected to "interoperability" on the technical side. The link with this theoretical technical potential is possible as SOA's core principle "open standards" allows all services to be easily connected via one standard. It would be easy to create interfaces between the dealer, importer and manufacturers of different car brands' services. It is thus possible to connect existing or new IS once they comply with these open standards, thus generating economic potential in the automotive distribution industry (18).

Figure 14: Spare Part Route from Manufacturer to Distributor

There are three distinct approaches for introducing a SOA in the automotive field (6):

- Approach 1: Department-driven SOA.

  Procedure: Individual department heads from process responsible division or process-related IT department's buy into the idea of SOA and develop an SOA strategy for their area, usually with the help of consultants or manufacturers of SOA solutions.

  Advantage: The business value of SOA is in the forefront and there is a concrete examination to determine which services increase enterprise value. The management attention needed for the department is also there, thus rapid progress can be made from the outset.

  Disadvantage: There exist the departmental boundaries. Generic services are rarely found, because these require coordination and possible compromise with other departments in terms of the customization of services. Departmental concerns may take precedence over standardization and harmonization. At implementation time, if not before, coordination with the central IT function will also be needed in order to conform to standards.

- Approach 2: Application-driven SOA.

  Procedure: Applications drop out of the maintenance phase or require an update or an upgrade. Many manufacturers of off-the-shelf software also make internal technical changes to their products. The opportunity may be taken to make these applications internally "SOA-enabled", i.e. functions will be encapsulated and interfaces converted for web services. "SOA-enabled" here means simply that the new applications are implemented as a number of statically independent services.

  Advantages: In this way, companies obtain SOA technology and SOA-enabled applications, even if they do not yet have any thoughts of constructing an SOA infrastructure. The development effort is no greater than it is for non-SOA-enabled applications, so there is no need to draw up a separate business case. Legacy systems can be replaced in an "evolutionary" manner, i.e. one at a time.

  Disadvantages: Without a SOA strategy or a "Service Roadmap", the result is just a local solution without any wider framework. Cross-application services, or breaking down a large application into service modules that can work together with any other services, possibly from other manufacturers, are not normally major goals for software manufacturers.

- Approach 3: Governance-driven SOA.

  Procedure: Based on a thorough analysis of the current IT environment, an enterprise-wide service-oriented architecture planned as a whole. As a rule, the implementation partners for the SOA infrastructure will be identified at an early stage. Often, past or present technology-driven projects (e.g. EAI) may be extended to cover the service philosophy.

  Advantages: This overall approach makes it most likely that the promised goals of an SOA in terms of non-redundant functionality and flexible linking of services will be achieved in the longer term. The pieces of the solution will fit together.

  Disadvantages: More time and effort needs to be factored in both for the analysis phase and for the design of the services, as the existing IT environments are complex with very many parties and their interests to be considered.

Without a clear commitment from management, the implementation will fail, as the business benefit is often hard to predict while the costs can be forecast all too accurately.

3.4. Comparison of Related Works and Proposed Solution

In the current IT project sphere in the automotive field, various approaches and procedures can be seen in place to improve the service-orientation of IT organizations and whole IT environments. The procedural model, applicable to SOA, specifies a continuous process which enables a process of evolutionary optimization and so provides for a smooth transition from legacy structures into a holistic, forward-looking SOA solution. In clearly defined phases and steps, concrete and usable deliverables are developed in the form of framework architectures, migration plans, recommendations for product selection, etc.

All three approaches mentioned in the previous section have their place, but it makes sense to launch an overall strategy, and to combine all three approaches where necessary. This may well happen at a coarse domain level and result in prioritizing a pilot, which comes closest to a department- or application-driven approach – for which the application-driven one is chosen for this study. Only those who have decoupled their process and IT components will have the flexibility and agility needed to be successful in the global automotive marketplace of the future (19).

4. METHODOLOGY AND IMPLEMENTATION APPROACH

4.1. Current Status for the Automotive Industry and SOA

The automotive industry is an important force in Turkish economy. It is rapidly growing and considered to become one of the strategic sectors. According to the surveys, in 2006 around 1.025.000 vehicles (cars and others) were produced and marketed in world markets. In 2006 the total amount of export of the industry is $14.4 billion which is at the top of the all Turkish export and covers 18% of all Turkish export amounts. This sector defines the basic infrastructure for the technological developments as the advancement of this industry supports the growth of the steel, plastic and glass industries as well as related spare parts production sectors (27).

The recent survey made by IDC shows that, the spending over the worldwide on SOA is likely to reach about $ billion by 2009. The other survey which is made by Aberdeen group says that 45% of companies surveyed have projects underway involving SOA in their supply chain and 17% plan to start projects in the next months (20).

There is an experimental result for a positive relationship between SOA adoption and performance of electronic supply chains and it is also found that SOA adoption helps to achieve better electronic supply chain performance.

Also, Motorola estimated that adopting web services based architecture helps savings of about $100,000 to $150,000. It was estimated that General Motors would be able to reduce operating costs by $1000 per vehicle by adopting web services.

4.2. SOA Adoption Evaluation Approach

Web services and SOA adoption improves the efficiency in supply chains. Thus, there is broad agreement that SOA adoption leads to improvement in supply chain performance. Hence, for our research setting of electronic supply chain, the following hypothesis are listed and these hypothesis are taken from the article “Impact of SOA Use on Performance Outcomes of Information” which is written by Sanjeev Kumar, Vijay Dakshinamoorthy, and M S Krishnan (20):

H1: SOA adoption leads to better electronic supply chain performance

SOA adoption impacts electronic supply chain performance. Hence, now focus on three main parts of an electronic supply chain: customers, suppliers and partners. Expected that electronic integration of customers, suppliers and partners into the supply chain would significantly affect the performance of the electronic supply chain.

SOA would improve the benefit by making real time communication and information sharing easier, because of SOA's standards based interoperability feature. Hence, a firm with SOA would be in a better position to with its electronically integrated customers, suppliers or partners to achieve better electronic supply chain performance. Thus, reach hypotheses 2, 3 and 4:

H2: SOA adoption increases firm's ability to leverage electronically integrated customers to achieve better electronic supply chain performance.

H3: SOA adoption increases firm's ability to leverage electronically integrated suppliers to achieve better electronic supply chain performance.

H4: SOA adoption increases firm's ability to leverage electronically integrated partners to achieve better electronic supply chain performance.

The hypotheses described above are summarized in the research model shown in Figure 15. Hypotheses 1 has been operationalized in the research model as a direct effect while hypotheses 2, 3 and 4 are interaction effects that moderate the relationship between electronic integration of customers, suppliers and partners and electronic supply chain performance.

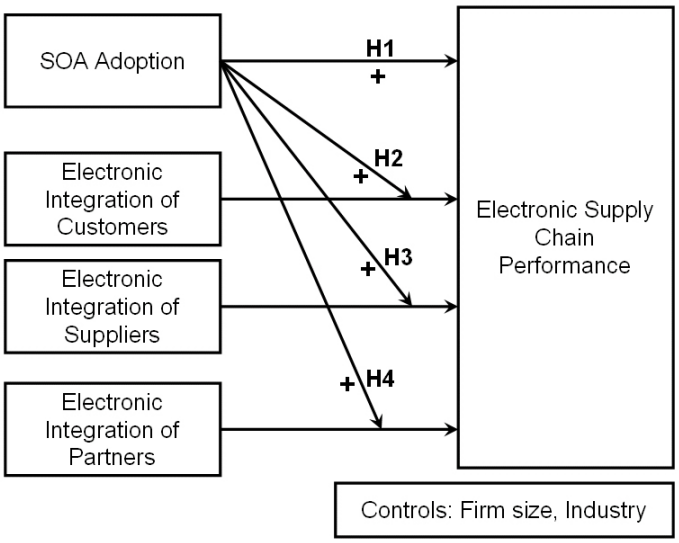


Figure 15: Research Model **(20)**

Kumar, Dakshinamoorthy, and Krishnan (20) suggest that the collected data can be used to measure the constructs being studied in the following manner:

Electronic Supply Chain Effectiveness (ESupChainEff): The proportion of total revenue that comes from electronic channels. Taking this measure as a proxy of electronic supply chain performance. Believed that this is an appropriate measure since if a company generates higher percentage of its revenue from electronic channels then the company can be considered to have a more effective electronic supply chain compared to a firm with similar characteristics but a lower percentage of revenue coming from electronic channels.

Electronic Integration of Customers (ElecCust): Electronic customer integration of a firm is measured as the percentage of the firm's customers that are included in its electronic supply chain.

Electronic Integration of Suppliers (ElecSupp): Electronic supplier integration of a firm is measured as the percentage of the firm's suppliers that are included in its electronic supply chain.

Electronic Integration of Partners (ElecPart): Electronic partner integration of a firm is measured as percentage of the firm's partners that are included in its electronic supply chain.

SOA Adoption (DSOA): The IT department in their firm has developed and deployed a companywide services-based IT architecture. This variable is coded as a dummy variable with all responses that identified wide scale deployment of SOA were coded 1 while firms that did not report wide scale deployment of SOA were coded as 0.

Firm Size (Firm Size): Annual revenue for financial year 2011 (in million dollars) was taken as a measure of firm size.

Industry (D Ind): Industry choices coded as either Manufacturing or Services. A dummy variable was introduced to capture the information.

Table 2: Ordinary Least Square ("OLS") Regression Calculation Variables for Direct effect of SOA Adoption on e-SCM effectiveness **(20)**

	Before SOA	**After SOA**
Electronic Integration of Customers	80%	94%
Electronic Integration of Suppliers	100%	100%
Electronic Integration of Partners	50%	100%
SOA Adoption	0%	100%
Firm Size	$18.000.000	$ 20.000.000
Industry	20%	85%

It is necessary to mention that the used data has been provided from the staff of the retailer. All numerical data which has been used here or at another part of the formulas are conveyed from distributer or retailer. At the field study part of the thesis, the collaboration between us and the firms (distributor and retailer) has been mentioned. If the parameter which has been used in the correlation formulas is

considered, it is seen that the values have been prepared for the retailer. So we contacted with the retailer and asked the estimated values for the parameters. In real life, they use a system which partially service based. For "before" values they based on the time zone before this application. For "after" values they consider the data after this system. And it is predicted to provide more affirmative result when a completely service based solution applied.

4.3. Field Study on the Scope

The studies in the field, includes the details of spare part supply chain from three different roles perspective. As general, if the researches are classified, it can be said that this process has three main parts like distributor, vendors, and outer firms. The process starts at foreign main source and ends at domestic end user. Distributor is placed at the center of this process. That is why distributor part is the most comprehensive part of this research. Distributor is the intervenor of this process.

Table 3: SCM Roles **(20)**

	Raw Material Supplier	Standardizer	Component Specialist	Integrator
Focus	A company that supplies raw materials to the Manufacturer of their suppliers	A company that sets the standard on a global basis for a specific component or system	A company that designs and manufacturers a component to a platform or vehicle	A company that designs and assembles a whole module or system for a car
Market Presence	• Local • Regional • Global	• Global	• Global for 1st tier • Regional or local for 2nd, 3rd tiers	• Global
Critical Capabilities	• Material Science • Process Engineering	• Research design, and engineering • Assembly and supply chain management capabilities	• Research, design, and process engineering • Manufacturing capabilities in varied technologies • Brand image	• Product design and engineering • Assembly and supply chain management capabilities
Types of Components or Systems	• Steel banks • Aluminum ingots • Polymer pallets	• Tires • ABS • Electrical Control Unit	• Stampings • Injection molding • Engine components	• Interiors • Doors • Chasis

4.3.1. Survey Results and Evaluations

In this part of the thesis the survey which is made for defining the problems and making evaluations on its results will be presented. The questions are defined after analyzing the process in detail. While questions and their choices prepared we have

taken help from employees who are working as analyzer of the process. After that, the survey presented to the distributors and vendors via web based application. According to the results, problems are identified and tried to find solutions. It is already seen that the survey results are support the problems that is found after analysis.

The list of survey questions, number of participants, and answer rates are given below. The evaluations according to this survey will be given next and the detailed explanation of each choice, its related problem, what it means when a choices rate become high or low will be explained it detail.

4.3.1.1. Survey Questions

- Choose your main group in process frame
    - Vendor
    - Distributor
- Which level take most of the time in spare part supply process?
    - Vendor side:
        - Defining the order lines
        - Creating the order
        - Approval process of the order
        - Supply process of the order
        - Logistics process
        - Delivery and locally depot process
    - Distributor side:
        - Approval process of the orders
        - Totally grouping of the orders
        - Supply of the orders
        - Shipment process
- In which level of the process errors are seen most?
    - Vendor side:
        - Defining order lines
        - Entering the spare part codes
        - Estimating the delivery time

- Distributor side:
  - Grouping the orders
  - Control of the main depot and listing the parts that are going to be expected from the center
  - Estimating the delivery time
  - Submission
  - Shipment plan, preparing the shipment
  - Logistics planning

4.3.1.2. Survey Results

Survey participation, rate of the participants, answers and their graphics with numerical values are shown in below tables.

Table 4: Survey Information

Survey Information	
Survey Definition	Survey that aimed to make implication according to the problems of spare part supply process in automotive industry.
Survey Url	http://www.bb.com.tr/scmSurvey/survey.aspx
Survey Participants	44
Survey Participation rate	Distributor: 25 (56,5%) Vendor: 19 (43,5%)

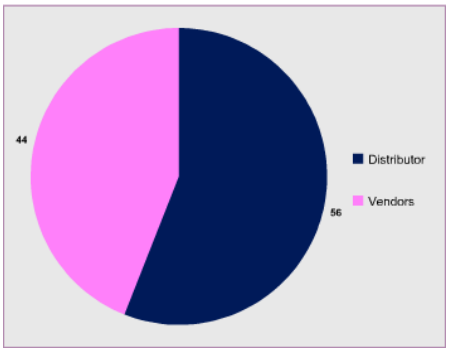
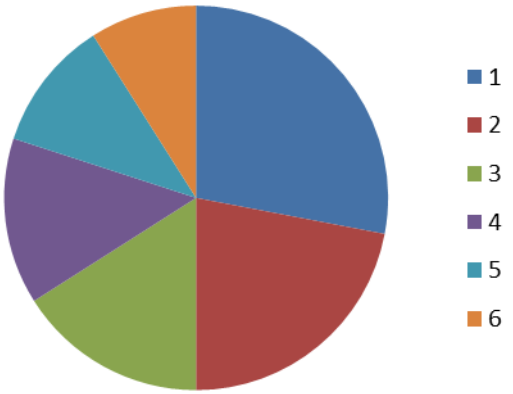


Table 6: Question (1) and Answer Percentages

Q1 – Vendor Answers	
1.Defining the order lines	28%
2.Creating the order	22%
3.Approval process of the order	16%
4.Supply process of the order	14%
5.Logistics process	11%
6.Delivery and locally depot process	9%



Q 1 – Distributor Answers	
1.Approval process of the orders	36%
2.Totally Grouping of the Orders	31%
3.Supply of the Orders	14%
4.Shipment Process	20%

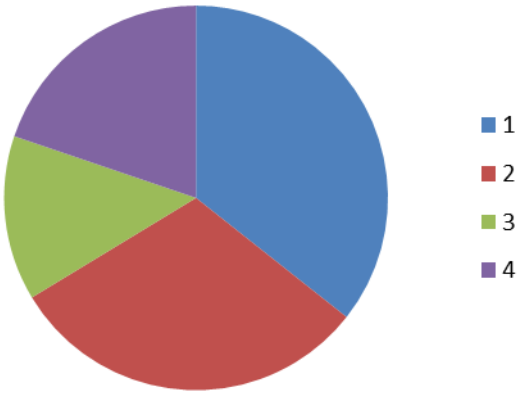
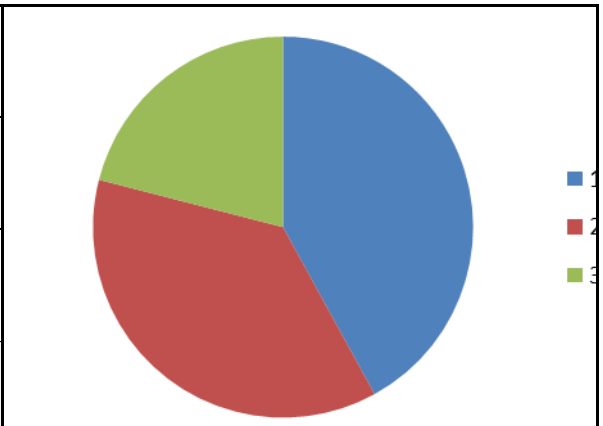
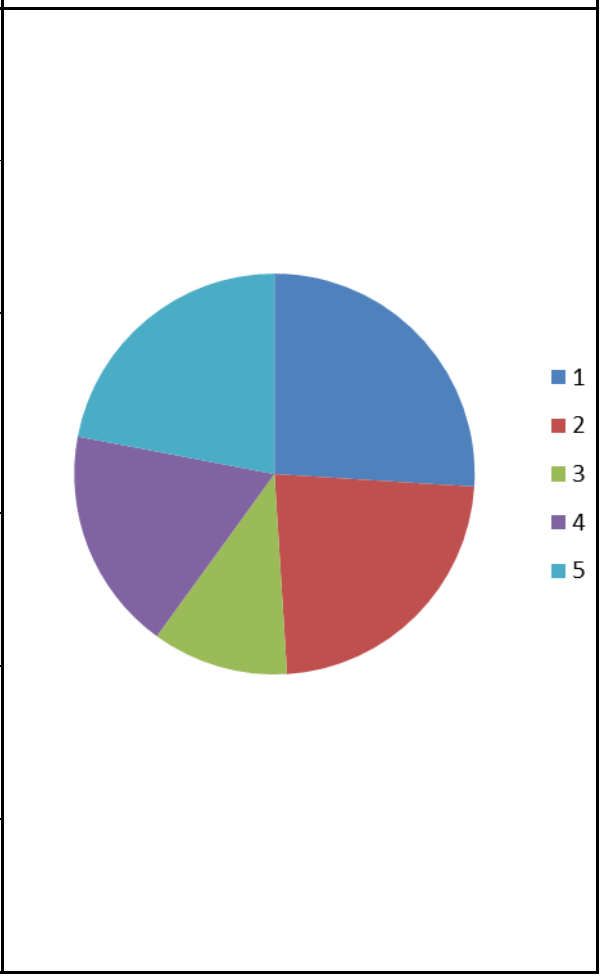


Table 7: Question (2) and Answer Percentages

Q2 – Vendor Answers		
1.Defining Order Lines	42%	
2.Entering the spare part codes	37%	
3.Estimating the delivery time	21%	
Q 2 – Distributor Answers		
1.Grouping the orders	26%	
2.Control of the main depot and listing the parts that are going to be expected from the center	23%	
3.Estimating the delivery time	11%	
4.Submission	18%	
5.Shipment plan, preparing the shipment	22%	

4.3.1.3. Analysis of Survey Questions and Answers

With the help of survey, it is aimed to find out the most problematic process of spare part supply process in automotive industry. According to the answers of the distributor and vendors, it is aimed to take information about in which process errors made mostly. In this part of the thesis, the analysis and evaluation is made according to the survey questions and answers. The reasons of given answers will also be discussed.

In the first question of the survey, the most time consuming process is asked when supply process is considered as a whole. According to the chart and numerical results given in Table 5, the processes are listed in Table 7 according to distributor and vendor employees.

Table 8: Percentages of Survey Results of Question (1) and its Answers for Distributor and Vendor

VENDOR		**DISTRIBUTOR**	
Defining the order lines	28%	Approval process of the orders	36%
Creating the order	22%	Totally Grouping of the Orders	31%
Approval process of the order	16%	Supply of the Orders	14%
Supply process of the order	14%	Shipment Process	20%
Logistics process	11%		

It is seen that, vendors give their answers mostly on identifying order lines and creating order. Order lines defining process includes sub processes like; overview of depots, determination of needs, planning the quantities. Because of the wrong planning there will be many problems like, depot localization problems, giving unnecessary orders. So, this process stays at top levels of time consuming.

Secondly, entering order answer is chosen. At this point, the most important thing is that spare part codes must be given correct and coherent with the center. In order to avoid the saving with wrong code or writing the codes wrong, both distributor and vendor side must obey an agreement. This is a process making an agreement with center and then orders can be created.

After sending the order requests to the distributor, the most time consuming level is approval process. This situation occurs while distributor giving approval to the orders. The supply process of orders is means that; related orders becoming ready for shipment at center. These processes will be mentioned also when analyzing distributor side answers.

The answers given by distributor show that, most time consuming process is approval of orders. At this level same things happen at distributor side like vendors side. Approval of coming orders and controlling of codes are done at this level. Also, totally grouping process is done here. Grouping same part requests coming from different vendors and order quantity- spare part relation is defined here.

The other choice having high rate is shipment process. At this level the main reason which causes time consumption is communication problems with the logistics firms at distributor side (unplanned/ unexpected shipment requests). Shipment process is planning the delivery plan by distributor.

Second question is asked to gain information about process in which errors mostly are made by both distributor and vendors. According to the answers at Table 6, the faults that are done in sub processes are shown in statistically at Table 8.

Table 9: Percentages of Survey Results of Question (2) and its Answers for Distributor and Vendor

VENDOR		**DISTRIBUTOR**	
Defining Order Lines	42%	Grouping the orders	26%
Entering the spare part codes	37%	Control of the main depot and listing the parts that are going to be expected from the center	23%
Estimating the delivery time	21%	Estimating the delivery time	11%
		Submission	18%
		Shipment plan, preparing the shipment	22%

According to survey results, errors are mostly made while defining the spare parts that are going to be ordered. This situation is in parallel with the previous question. In fact, if the first question its answer and analysis is considered, it is seen that errors can occur while making depot localization and determining the expected consumption amount of spare parts and making orders. These errors are occurring because of there is not a decision support system and processes are done according to experiments and observations.

While entering spare part codes, human based errors are mostly seen. Entering spare part codes falsely or not reflecting the changes on spare part code to the vendor's side causes demanding wrong orders. This situation mostly occurs because of the coordination problems.

The other important process in which errors are made is estimation of logistics time. If vendors could not estimate the orders coming time correctly, there can be problems with customers and they cannot plan their processes correctly. If they do not make an implication according to the previous shipments, then there occur problems.

When statistics of distributor answers analyzed, it is seen that mistakes are made while grouping the orders. At this stage, orders coming from vendors are grouped according to the spare part codes. Here there can be problems that may occur because of the spare part code differences. Because, changed spare part codes seldom accepted as different spare parts coming from different vendors. This problem occurs because there is no integration between center and vendors for storing spare part codes. So, it is hard to define, according to all vendors orders which spare part and how many of that spare parts are demanded. This situation causes mistakes at this level.

Another mistake mostly done is, distributor makes own supply plan. At this stage the determination of depot areas of spare parts and which spare parts should be requested from main source decisions are made. Because of the personal mistakes, some spare parts accepted as not existing in depot and demands are made from main source for this spare part. This situation makes the supply process longer. Also, by this situation existing spare parts waits at depot area too long. So, this causes more depot costs.

Logistics planning is another level that mistakes can be done mostly. At this level, mistakes such as wrong route definitions, communication problems with shipment firms, and wrong definition of shipment orders are made.

Taking the delivery choice in survey answers is related with the distributor own delivery taking process coming from main source. This choice enclose the problems such as transportation of spare parts coming from main source to entrepot and then to the central depot areas. These problems occur because of the disagreements of spare part codes with main source, disagreements of delivery locations, and customs problems.

Estimating delivery time is another problem for distributor side. Mistakes that made in this process because problems like incorrect and timeless shipments to vendors, so, there will be problems between end users and vendors these problems also reflect to the distributor. The problems occur because of the unplanned order intensity. The order intensity can be planned according to the previous spare part movements.

When the survey results are analyzed, related answers with the processes and problems that are considered are seen that they are intensive. The proposed approach

(with service oriented central structure, integration, presentation of data to the clients inside system) is overlapping with the survey results.

4.3.1.4. Explanation of Numerical Parameters

The numerical results and rates, how they brought up, which implications are made and employees (distributor and vendor side) helps to retrieve these data explained in detail in this part.

- **Processed Total Part Quantity:** This parameter is used in Jordan & Graves method. It is named as intensively processed total part amount and its value is 50.000. Employees work in distributor's depot area said that the whole part quantity is more than 50.000, but some parts are not processed more than 2 years. So, for this kind of evaluation 50.000 spare parts is a usable quantity.
- **Chain Number Calculation:** This calculation is used in Jordan & Graves method and chain number is explained at section 5.1. Here, different chain numbers are defined. 120 is used for before value, 35 is used for after value. Main source works with many behalf firms. These firms are made productions at different countries. Then they deliver their products to the main source. Main source orient its spare part purchasing according to the plans coming from country distributors. The number of manufacturers that the firm works and supply spare part approximately 80.

  It is specified by the depot employees that inside 50.000 spare part every 5 spare part is in same group. The group mentioned here can be explained like this; spare parts such as, lock arm, lock head are grouped as lock parts for any brands, any model.

  According to the Jordan & Graves method chain number, for 10.000 part group if supplied from different 80 manufacturers is 120. In consequence of presented approach benefits, ensuring any spare part from several manufacturers more than before and ensuring more kind of spare part from a manufacturer is possible. Through this, chain count which has been occurred for the same amount of part group is reduced to 35.
- **Percentage of Electronic Integration of Customers:** For the calculation of this parameter, vendor data are used. A sample vendors bookkeeping

application, all customers also before the digital platform are recorded. The customer number is 66945 (includes vehicle sales and service). Now, vendors are used e-SCM which is used partially service oriented architecture and recorded customer number is 62928. This rate equals to 94% percent. Vendor side CRM employees said that this e-SCM process can be able to record 10000 customers to the system. So, it is estimated that customer number in digital platform is approximately (62928-10000) 53000. The used rate (80%) for the comparison is coming from here.

- **Percentage of Electronic Integration of Partners:** This parameter shows that, how many of the partner firms (role based) included to the electronic process. The role based partner firm number is 2. These are insurance and towing firms. Before SOA structure is used, only insurance firms are exist as different role. They can follow the insurance processes from the system according to their authorizations. After SOA architecture is used partially, towing firms merged to the system. With the help of services towing firms authorized, they can list the work orders with the parameters they give. So, previously rate 50% has become 100% with two partners included to the system.
- **Firm Size (Vehicle Sale and Service revenues):** The total movement of 2010 quantity is declared by vendor employees approximately 20.000.000$. The vendor executives said that there is an increase at rates with 11%. This 11% includes service oriented approach benefits such, right planning with the help of services, decreasing mistakes, fastening of shipments. This positive improvement increases the customer satisfaction, service and sales customer number and process volume. (with the improvement of 11% the total movement amount become 20.000.000$ from 18.000.000$).
- **Industry (Percentage of Electronic Integration of Process):** During the processing which is related to this parameter it explain how many section it include about during to e-SCM processing which is before and after SOA. Given all the process under the title of after-sell services, before SOA supports the structure, just the service records taken and work order records associated with the customer were made. After then , partially service-based structure with SSH process can store all the details of the process in each record transactions after creating a service record(work order), details of

labor positions, parts details, service details, all transaction status, workshop information, workers' information, including the estimated completion time can be tracked and stored in an e-SCM system according to the these information to make allowance for during the all SSH processing time before and after processing percent is 20% and 85% which consists of electronic process to form an estimate.

4.4. Study on Distributor

Distributor is a unique establishment or one of the agents that is authorized by producers for selling products and services.

Nowadays our country contains lots of distributor establishments that are situated at the center of the automotive industry by relating with abroad manufacturers. In our country automotive industry makes a big exploit and became an important participant of Turkish economy.

As mentioned above, because of the main producers positioning abroad, there is a huge chain which affects many sectors and profession, is started from abroad and ended in Turkey. Distributors operate to plan these processes, carry out them according to their standards and reach the targeted position. The processes that are mentioned here are import, domestic transportation network organization, planning, selling, after sales services, customer fulfillment, and human resources. The subject of this thesis is to constitute a supply chain management process to encompass these processes. Spare part supply as a sector is an important time indices has to give service to previous and present products of brands. So, this process includes intensive movement and labor.

The research is realized during one week at the logistic center of the distributor which owns selling rights of the most important marks in this industry. Spare part supply process was asked from different employees having different authorizations and tried to pursue the process in real environment, stock centers, and depots, logistic movements start points examined detailed and getting useful opinions about the process.

Spare part supply starts with the request of end-user. The end-user mentioned here is the service customer who takes his car to the repair service. Sometimes, this end-user may be an external firm that provides spare part needs partially from authorized service. The spare part order is sent to the distributor company by authorized service in dealer network. At this point orders are delivered to distributors in two ways. First one is urgent orders and second one is the stock orders. Urgent spare part orders are sent to authorize service at most in one day by distributor. Stock orders delivery times take at most one week. Distributor can equilibrate these two order types according to their profit margins.

Distributor makes spare part supply from abroad main source to its own stock. Distributor submits the parts that already exist in its factory to wellhead and request parts not included in its stocks from abroad wellhead. At this point the orders that are created have certain types. According to their urgency and delivery type (urgent, very urgent, plane stock, wheel stock) orders types take form. For some specific parts (stock cards) whatever their order type is their delivery will make urgently from domestic or abroad.

After this supply chain process logistics and storage processes step in. Distributor's storage process starts with the collection of spare parts in storehouse which are coming from main source. Storage house places are harbors, airports and strategically located collection areas. Incoming stocks are transported to distributor's depots according to their shipping scope by cargo companies or logistic network.

Distributor's depot movement process starts at entrance section. There are two types of entrance unit in depots. The first one is cargo entrance and the second is wheel entrance. Cargo entrance is used for low quantity of emergent part entrance. These parts located their related places after their depot entrance is made. For a general order and ease of transport, depots are divided into avenues, streets, shelf and cells then placement is made according to addresses.

The other important part of storage process is the shipping to domestic vendor network. There are made some arrangements at depot exits to make shipping effectively. Distributor has seven depot exit gates, one is for urgent and the others for region exit. There exist six exit gates because they divide country to six regions.

Emergency gate is used for nearly located vendor's shipments within day. Other gates are for regions. According to vendors locations and consistencies in network distributor specifies these six region gates, each gate points a region. Each gates region and vendors are assigned.

Another important detail in distributor's depot area is each location in vendor network has an imaginary region. Spare parts that will ship to the related vendor are collected from their depot places and stored in that virtual area. The next step is collection from this virtual area and sending to the exit gates. After that point, placement will made according to route and first in last out logic then shipment will start.

At the last phase, shipment will end at authorized services (vendors). Delivery is made to vendor's entrance place and vendors make their placements in their depot areas.

4.5. Solution

4.5.1. Sample Scenario

The sample scenario includes the existing roles in supply chain management. As known, the instance industry is automotive and the supply chain management schedule of this industry includes the roles of abroad main source, distributor, vendors, logistics, outer firms (out of the vendor's network) and the end users.

The start point of spare part supply chain is the end users. Firstly the customer comes to the service and the spare part demand occurs. The reason of this service visit may be the periodic maintenance, after an accident or a complaint of the user. Service employee checks and saves the car, and lists the spare parts that will be used for this car. After that point, a work order is created according to the car needs.

If the spare parts that will be used are already in stock it is used from there. Sometimes the necessary spare parts may be out of stock. The reason of this situation is negligence of stock planning employee while making stock order plan. What if there is no related spare part in stock then service person should inform his officer to order the lack parts. Then officer make an order list to the distributor, the order types can change according to its emergency. If order is urgent this will be sent in one day

by the distributor otherwise the sending time will take 1 week. If vendor makes urgent orders its profit margin will decrease per spare part. But there is a chance that ordered spare part is not included in distributors stock, at that point distributor makes an order to the main source which is in abroad.

At the side of order data transmission, sometimes inconsistency situation is encountered. For example the vendors check the reserves for a spare part by a code; they see the controlled part is out of stock. But actually the part exists at the stock and the given order is unnecessary. On the other hand, vendors create the part orders according to the last order of the related part. And during that period, the part code may be changed. Similarly, the other firms request some special parts from the vendors (as the bank sales) and they may present the wrong data to the vendor. Because they are outside of the central association. The lack of a central association causes lots of problems.

Main provider sends order via ships or trucks. Urgent ones will be sent via cargo. Distributor has two types of entrance at their stock area. One for urgent orders they enter from cargo entry and the other ones enters from other gate called truck gate. There are 6 exit gates because they separate Turkey to 6 regions. The spare part orders leave stock area according to their order regions. Spare parts located into trucks according to vendors locations, the method applied is first in last out.

4.5.2. Modeling of the Solution

In this part of thesis; roles, processes of these roles, flow of processes, connection of these flows to services, solution of all these processes and aspects will be explained.

Firstly, role structures were determined. This is the most important step. Instead of integrating the roles in general SCM definitions to the modeled solution, these role structures arranged according to the modeled solution. This means that general SCM roles are specified according to modeled solution in this thesis.

The mentioning small changes in SCM roles here are, firstly the distributor place at the top of applied segment like supplier. Secondly, according to sector structure there is only one supplier in supply chain structure. This means that all brands, all parts are

taken from one supplier. Lastly, the retailer role in SCM is equalized vendors in modeled solution.

In SCM concept generally retailers placed in different locations with different corporate structures and independent from each other, in this modeled solution vendors placed in same network with same structure, all business processes processed with same rules.

In addition, there will be external companies which are not included in vendor network. These companies do not have to obey the rules defined by distributors because they are independent and they can be joined spare part supply process. So, the solution covers that situation also.

Definition of the roles and followed steps can be listed as;

- Identification of the roles in the scenario.
- Identification of all operations of roles in supply process.
- Identification of flows of these roles.
- Adoption of flows to main parts of scenario
- Performing modeled structure with a service oriented solution and identification of a system plan for management

Up to now, the detailed explanation of the first stage of the solution was made. In this first stage, the right model of the whole process and scenario which is compatible with the study threatened. After this part, the offer about SOA based system structure and the ways how to carry out this structure will be mentioned.

In proposed solution why SOA based structure is used and its advantages are mentioned. In the proposed solution it is aimed to use SOA in right way to gain maximum advantages.

Actually, service structures mostly are specified when role processes and connection of their flows to main service lines were being defined. Determination of the basic services study is partially done. At this point, it is meant that from services; order, stock, logistics and guarantee main services.

BizTalk Server is placed at the center of the solution because the proposed solution presents connected services and these services integrate and communicate with each other. For example, if there is a need to learn stock quantity of some product the stock quantity information service will return the number of quantity in the stock, what if there is an open order about that product which will be stored to the stock, at that point services must communicate with each other and accumulate the quantity in the stock. In the proposed solution, communication between the services is considered as a necessity of SOA based approach.

Database structures which are the source of data flows, stored in database server. SQL Server 2008 which is used as database server, are provides the usage of data coming from Microsoft .NET platform applications, Microsoft BizTalk Server based SOA architectures and business processes. SQL Server 2008 presents continuity, productivity, scalability, security and performance features together and low cost. These features are important for critical processes. In the further sections, this performance improvement will be shown with the numerical proofs and it puts forward the proposed solution from previous SOA based, database server used solutions.

In the proposed solution, features like modularity, and management at one point are provided by integration process which is work as a service. Presence of integration service provides the change in the whole system (all parts and data sources) when a part code change made at one point of the system. Operation and working logic of this service will be introduced in Section 4.5.3.

In the solution firstly the real members of the supply chain model are determined. After this, their work flow patterns and child processes of these patterns are decided. This way provided listed form of all data density. Here are the roles and their process model listing below:

Main source (abroad)

- Receive order from distributor
- List and filter order records
- Shipping process of these orders

Distributor

- Receive orders from vendors
- Receive orders from other firms (optional)
- List and filter orders
- Gather orders at a unique format
- Shipping process of these orders
- Operate return schedule
- Operate the warranty schedule
- Operate campaign, discounts and offering processes

Vendors

- Place orders
- Follow these orders
- Receive orders from end users
- Receive orders from other firms (bank sales)
- Operate the return process
- Operate the warranty process
- Plan their local reserves
- Make deductions by previous data

Other firms (out of vendor network)

- Request an offer
- Place an order
- Follow the order records
- See the reserves
- Plan its own reserves
- Other similar operations as vendors…

Logistic firms

- Plan the route plan
- Organize the fleet of vehicles
- True mapping between vehicles and drivers
- Follow the shipment process

- Create and present reports of shipments

End Users (involved operations)

- Arrive for the service
- Register to the system
- Create the work order
- Determine spare part requirements
- Determine labor process
- Warranty and insurance operations
- Delivery of the car

As seen above, the workflow and main processes are shown obviously. When a detailed investigation is made, it is seen that there are some main processes that include some child processes, and all the members use different way to realize them.

There is an application included in solution scenario which is querying via services from database structures. This application is list order, order detail, stock, stock movements information by using related parameters. Presented data is given in XML format and this provides the usage of data in many external platforms and applications easily. The thing here that emphasized with modeled solution is that the architecture has a service oriented and modular structure so it can work with external solutions and integrate them easily. The biggest example is Microsoft SharePoint Portal structure because it can be fully integrated with BizTalk.

BizTalk takes coming data into the system by its adapters. It is like a translator because of the structure which support many protocols and structures. At that point, a planning structure can be integrated the system because of the querying services like stock movements, order quantity. Offered planning structure is based on specific date interval orders and making intelligent order offerings. This ruled based structure can be installed with the integration of BizTalk.

In the solution model proposed BizTalk Server is situated at the center of the work. All mentioned processes are included in a service. The usage and access rights, authentications and authorizations are being controlled by BizTalk Server such as document management systems, mail-web servers control, web services control,

databases and other software system's controls. All members are included in this central structure.

The solution includes both database systems and web services. There are different database systems for different roles of supply chain. But they are all in the same chain. BizTalk Server allows them using just the same services but filtering different data. Similarly their local stock information, all the locations holds their own reserves at the side of themselves. But basically the spare parts and their codes are unique.

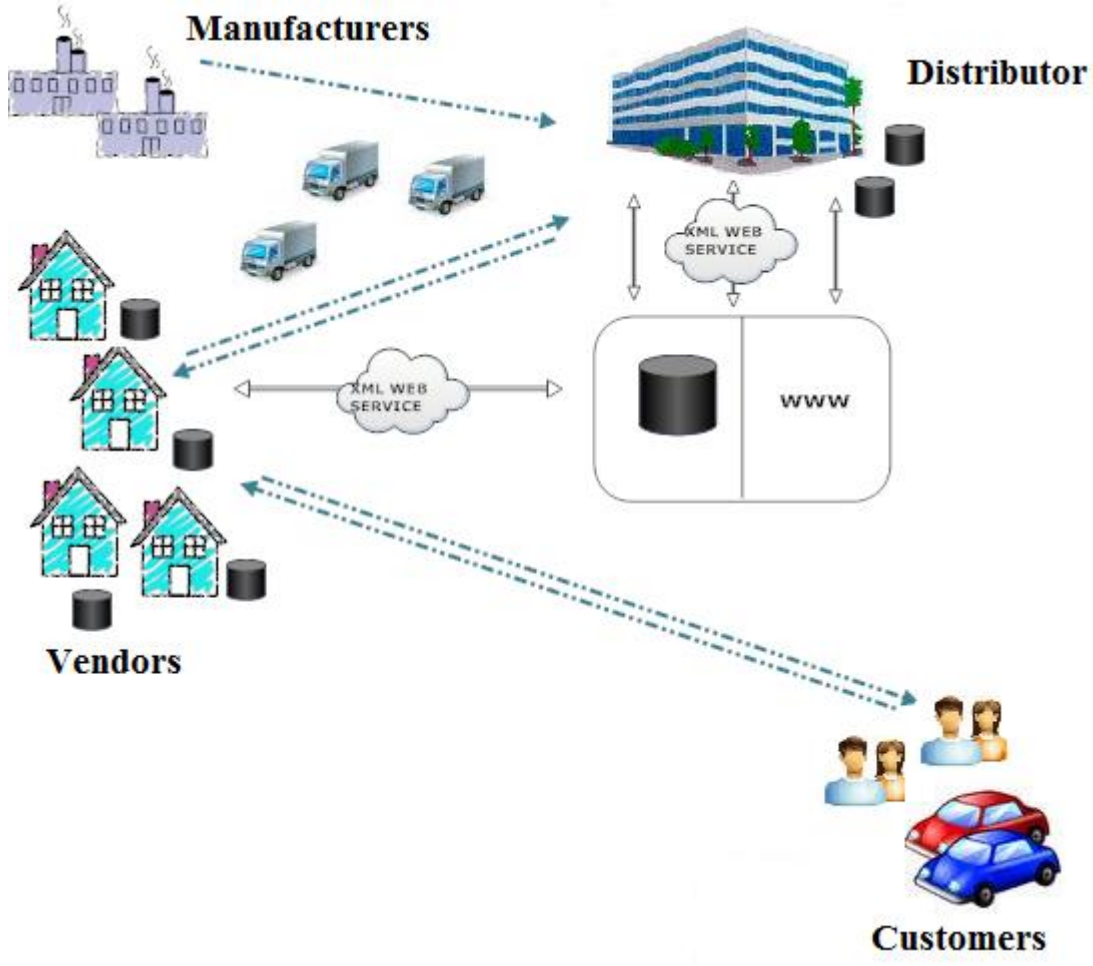


Figure 16: Sample Model of the System

As a result, presented solution is based on SOA strategy. As you can see from numerical results and comparisons in results part the strategy is applied in a right way by the correct modeling of roles, processes and sub processes. The system

background and basic skeleton of solution scenario is shown then modeled application and services constructed on that skeleton.

4.5.3. Application

4.5.3.1. Scope and Definition of the Application

The application of sample scenario and modeling of solution project with SOA infrastructure is explained in detail in the previous section. While modeling is realized spare part procurement steps are showed in detail and process steps are algorithmically shaped.

In this section, the designed model application will be introduced which is based on established problems and performed solutions. The application can be defined as a software application includes web services which cover the solution of two main problems of SCM that are spare part code data discrepancy and local stock planning inadequacy. Mentioned services are written with XML language, convenient to SOAP protocol and based on SOA infrastructure. The presented web services which are appropriate to SOA infrastructure principles can be queried by different roles from one point. With respect to showing references web services can communicate with each other.

4.5.3.2. Web Services

Web services are XML based messaging procedures for integrating systems. According to the definition made by W3C web services is a kind of software system that can be enabled computers interact and coordinate computers over a network. Nowadays, web services are the most preferable way to certify corresponded systems.

While selecting written web services, order, stock and integration services selected as a reference to the whole solution. Services are written as a model with SOA infrastructure for the solution of these process operations.

Services are discourse to the different roles like retailers and suppliers in spare part procurement process. Differently located vendors which are having different roles

can take data from same source according to their needs with same methodology. There is a coding system used in services for defining vendor's identity, role and data source. The key given to each service client is taken as a parameter from all services. So, application makes authentication and authorization via this key.

- *Order listing web service*: this service retrieving existing order data, filtering according to its parameter. Furthermore, this service decides which table of which database will be queried with which parameters and finally returns the rows. These services take product code, order status, related user (or supplier), start and end dates as parameters. The initiation of giving these parameters belongs to the service user. For example, if only one product code entered as parameter the orders which are related to this product will be listed. If no value entered as parameter or default value entered then service will executed for all stock carts.
- *Order Detail Listing Service*: it is normal an order have more than one record in it. When an order is created there can be more than one detail of data from different stock cards with different quantities which are recorded to data source. Thereby, if we consider order object as a whole, it can be discussed about its date and owner as general information and also the more than one detail information record. This service lists order information and details according to order code taken as parameter.
- *Stock Movement Listing Service*: Stock cards movements recorded to data source plus or minus above order demands. There is a constant stock flow between the supply chain roles like producers, suppliers, retailers and end users. This service listing stock cards (or selected stock card) according to a specific date or type with source-destination information.
- *Stock Information Service*: this service retrieving data about stock definitions which are located in different places. As detail mentioning below; with the help of integration service, there will be no data inconsistency because stock card definitions are recorded in local differently this causes confusions between data but integration service is a part of SOA avoid this disorder. This web service provides us holding type and stored data of a stock card at the locations of supply chain when needed.

- *Stock Quantity Information Service*: This service is listing stock source quantity of a stock card included in supply chain. It takes parameters as; service which takes stock card, client type with the help of key code like other services, finding data source way and returns stock card quantity.
- *Integration Service*: This service is different from other services in point of working principles and treatment. So, this service does not retrieve data, it has a functional structure. As mentioned that as an important problem; the discrepancy between data because of the difference between storage in different supply chain locations, integration service is the part of the SOA Based infrastructure. This service makes the integration between the locations inside the supply chain and the central base data source stock cards.

  So, with this integration service, if locations make different definitions, all stock cards are associated with center. In supply chain management process all operations related with stock card will be carrying out according to the code based on the center data source by integration service.

  Integration service work in specific intervals (these intervals can be defined by system administrator) and for all stock cards it will visit each data source. If there is change in a related stock card integration service will update the local source information. Also, if there is a stock card which is not defined at local but already exists in center then this stock card will be created in local by this service.

4.5.3.3. Database

The spare part supply process which is covered in this thesis is a huge process from data intensity. There is high data traffic within each step of this process. Data source structure and form is very important for the right and consistent data storage, querying different and independent locations in an efficient way and accommodation to SOA infrastructure distributed structure.

So, the data are stored in databases which will exist in the solution scenario. As understood from the definition there will be more than one database structure. There will be different structured databases for differently located supply chain roles. Also, there will be a central database as a part of modeled solution. It is useful to mention

here that all database structures tables and field definitions are made according to the needs of modeled application process flow. The important thing here is to make a prototype to the modeled system not a detailed and comprehensive optimization of database projection.

In this thesis retailer is centered to the modeled system. According to the supply chain management fundamentals retailer role points the firms which are included to the vendors' network in our scenario. These firms' stock movements, orders, customer information, shipping movement information are stored in database.

Second important role is supplier. As retailers' vendors are located at the center of our project, the retailer role points the distributor company. Distributor is responsible for collect orders from retailer's network, convert these orders to work orders make shipping, and send offers to firms that are not involved to vendor's network. All processes about supplier mentioned above related information of supplier firm are stored in supplier database.

Thirdly, central database is the most important database of our system. All other data sources use integration service to connect center database and create or update their contents. Definitions of stock cards and catalog information kept in center database.

There are differently rolled supply chains in system they also have different databases, by the help of integration service stock card implemented directly these databases. There can be different part codes defined by system administrators in different locations this causes data discrepancy but it will be solved by a unique key which verifies the connection to the central database.

Different roles of supply chain in the applied solution are mentioned. Central database should be used to arrange the role's authorization abilities and services that will use thereby queried data should be determined. In central database tables, roles that included in system, keys for the role's authorization and authentication processes, fields that points to the data sources are kept.

5. RESULTS AND EVALUATION

5.1. Outputs and Calculations

The main result of this thesis is to bring an academic research work to the literature which takes spare part supply as a subject and modeling it via service oriented architecture. Within the scope of this research previously made same subject researches were taken and examined. Generally, encountered position is specified problems and their solutions are sectional. Another situation that met is the solutions did not address the all chain parts or they intend only one sub process.

In this study the solution which was modeled covers all details of the process. A SOA based solution is modeled and this solution intends all roles in the supply chain.

At the end of this study, all roles of parts in the spare part supply process, their missions and the processes that are carrying out are specified and explained. By means of this study all main and sub services which are needed for business model are specified. Purchase order, stock, delivery and logistics main subjects and their sub processes were put in an order. This is provided by the usage of service oriented business rules.

Service oriented business rules are provided by different services like web services, document management systems, planning applications, or server management. All these services are integrated and enabled to communicate with each other. Main thing inside the application is providing this integration.

The rule based modeled solution in which services can easily communicate with each other is developed via BizTalk Server which is one of the solutions of Microsoft for integration and connection server for complex systems. BizTalk provides the ease of connection between separated systems in our solution. As a result BizTalk presents us the most productive environment to constitute a SOA based solution.

In this thesis study a solution model has been introduced and mentioned about its flexibility and useful features. Now, critical evaluation parameters of SCM process examined with numerical values and formulas. The first thing that will consider is SCM process flexibility. Flexibility is an important point of SCM management

because of the competitive environment of automotive sector, customer requirements have to reply just in time and it can be provided by the process flexibility of SCM.

Process flexibility provides system to reply sudden demand fluctuations and this gives big advantage to companies to compete. But, if this flexibility type cannot be gained to the system in a right way then costs go beyond utility. Because of that, process flexibility has to apply SC in a right way. In the systems that SOA applied correctly process flexibility shows positive changes.

For modeling this situation Jordan & Graves principles will be used. Jordan & Graves principles directly calculation rules and formulas that calculate SCM efficiency.

Before starting to examine the Jordan & Graves model, accepted assumptions have to be determined. According to this model assumptions can be listed for m unit product produced in n unit production area;

- Any product I and its demand di (rational variable) and total demand Di, average μ and have a normal dispersal standard deviation σ.
- The correlation factor between product demands ρ is same.
- All product area has same capacity c.
- Products and production areas placed in K unit chain and the product per chain is α and production area per chain β.

$\alpha = product/\ chain = m / K$

$\beta = product\ area / chain = n / K$

In j^{th} chain total demand (D_i) and j^{th}chain total product selling amount (S_j) equalized to each other with small differences. For each chain product assignment decisions is enough for reaching the utilities of flexible system. As a result of this enumeration the selling amount of j^{th} chain will be equal to product capacity or smaller product demand (D_i)

$$S_j = min\ (\beta c, D_i)$$

Because of D_i is equal to total amount of normal dispersal rational demand variables it will show normal dispersal with the following parameter.

$$E[D_i] = \alpha\mu$$

$$V[D_i] = \alpha 2\sigma + \alpha(\alpha - 1)\, 2\rho\sigma$$

$$= \{2\sigma 2\alpha\rho + \alpha(1 - \rho)\}$$

Here;

E $[D_i]$: j^{th} expected total demand of products in the chain

V $[D_i]$: j^{th} variant of product demand in the chain

Above definitions shows in turn the standard normal frequency dispersal function and cumulative dispersal function and the j^{th} chain expected total selling product amount can be found with the below equation:

$$E[S_j] = \int_{-\alpha}^{\beta c} x\phi\left(x - E[D_i] \Big/ \sqrt{V[D_i]}\right)dx \; + \beta c(1 - \Phi(z))$$

$$z = (\beta c - E[D_i]) / \sqrt{V[D_i]}$$

If $E[D_i]$ and $V[D_i]$ variables in (2) and (3) numbered equations are put into the above showed $E[S_j]$ equation and the integral will solved that below equation is accessed.

$$E[S_j] = \alpha\mu\Phi(z) - \sigma\sqrt{\alpha^2\rho + \alpha(1-\rho)}\phi(z) + \beta c[1 - \Phi(z)]$$

Total amount of selling in the whole chain is equal to T.

$$E[T] = m\mu\Phi(z) - \sigma\sqrt{m^2\rho + Km(1-\rho)}\phi(z) + nc[1-\Phi(z)]$$

$$z = (\beta c - \alpha\mu) / \sigma\sqrt{\alpha^2\rho + \alpha(1-\rho)}$$
$$= (nc - m\mu) / \sigma\sqrt{m^2\rho + Km(1-\rho)}\ .$$

In some situations, especially in balanced situations of total expected demand and total capacity, these equations makes easier the analysis.

z=0, $\phi(z)$ =0,3989 and $\Phi(z)$ =0,5

the equation will become

$$E[T] = m\mu - 0{,}3989\sqrt{m^2\rho + Km(1-\rho)}$$

Namely, when chain number (K) decreases, expected total selling number will increase. So, by decreasing the chain number in SCM and increasing as possible the number of product- product area chain, then selling amount will increase and earning yields will be improved. From the figures above chain number is obviously seen. It is called chain to the connection which modeled on a line which cannot be broken between product and product places.

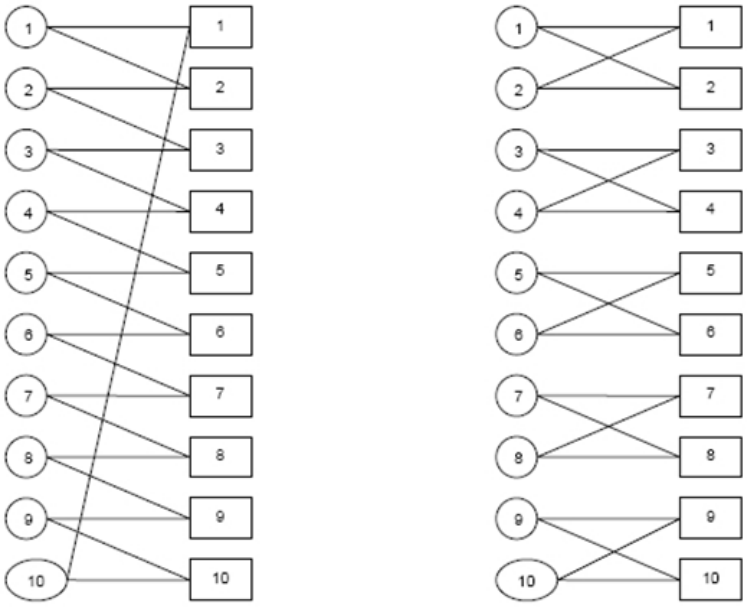


Figure 17: Different types of Chain (30)

It can be assumed as constant variables that the standards deviation and correlation factor variables which are placed at the last level of the formula for before and after of presented solution.

Table 10: Sample Variables for the Calculation

	Before(1)	**After(2)**
m	50000	50000
ρ	0,5	0,5
μ	1	1
K	120	35

$$E[T] = m\mu - 0{,}3989\sqrt{m^2\rho + Km(1-\rho)}$$

With the SOA based solution, data can be queried with BizTalk adapters from single center immediately. These data can be formatted as accepted from other platforms. So, this data (total number of order for a stock code based on vendor network) can be followed by distributor and shared by main source and producers.

With help of this situation, products product area variant are expanded and chain structures that are independent and broken from each other are decreased. So, in a specific process, selling quantity and process flexibility parameters are seen as higher value.

Four analysis models were tested using the variables to test our hypotheses which are mentioned at Research Study Section. The first model tests the direct effect of SOA adoption on electronic supply chain effectiveness. Next three models test the interaction effect of SOA adoption on the relationship between electronic supply chain effectiveness and electronic customer integration, electronic supplier integration and electronic partner integration respectively. The interaction effects are tested separately so as to not confound their effects. The four model specifications are detailed below:

Model 1: Direct effect of SOA adoption on electronic supply chain effectiveness

$$\boldsymbol{ESupChainEff = \beta 10 + \beta 11\ ElecCust + \beta 12\ ElecSupp + \beta 13\ ElecPart + \beta 14\ DSOA + \beta 15\ FirmSize + \beta 16\ DInd + \varepsilon 1}$$

Model 2: Interaction effect of SOA adoption on relationship between electronic customer integration and electronic supply chain effectiveness

$$\boldsymbol{ESupChainEff = \beta 20 + \beta 21\ ElecCust + \beta 22\ ElecSupp + \beta 23\ ElecPart + \beta 24\ DSOA + \beta 25\ FirmSize + \beta 26\ DInd + \beta 27\ ElecCust * DSOA + \varepsilon 2}$$

Model 3: Interaction effect of SOA adoption on relationship between electronic supplier integration and electronic supply chain effectiveness

$$\boldsymbol{ESupChainEff = \beta 30 + \beta 31\ ElecCust + \beta 32\ ElecSupp + \beta 33\ ElecPart + \beta 34\ DSOA + \beta 35\ FirmSize + \beta 36\ DInd + \beta 37\ ElecSupp * DSOA + \varepsilon 3}$$

Model 4: Interaction effect of SOA adoption on relationship between electronic partner integration and electronic supply chain effectiveness

$$\boldsymbol{ESupChainEff = \beta 40 + \beta 41\ ElecCust + \beta 42\ ElecSupp + \beta 43\ ElecPart + \beta 44\ DSOA}$$

$$\boldsymbol{+ \beta 45\ FirmSize + \beta 46\ DInd + \beta 47\ ElecPart * DSOA + \varepsilon 4}$$

The models above were first tested using Ordinary Least Square ("OLS") Regression.

The results support our first hypothesis that SOA adoption improves electronic supply chain effectiveness. The coefficient for SOA adoption in Model 1 ($\beta 14 = 6.8$, pvalue 0.014) is significant and positive indicating that firms that adopt SOA derive higher proportion of their revenue from electronic channels for the same amount of customer, supplier and partner integration in their electronic supply chain (20).

In Model 2, the interaction between electronic integration of customers and SOA adoption was found to have a positive and significant relationship with electronic supply chain effectiveness, providing support to hypothesis 2 that SOA adoption moderates the capability of the electronic supply chain to leverage electronically integrated customers (20).

Model 3 and Model 4 failed to support hypotheses 3 and 4 respectively as the coefficients for interaction between SOA adoption and electronic integration of suppliers and partners respectively were not significant. This indicates that adoption of SOA does not significantly impact firm's ability to leverage their electronically integrated suppliers and partners to generate higher revenue from electronic channels. Related calculations are made based on the Table 13 which is given at appendix (20).

Results show that SOA adoption improves the customer-side effectiveness of electronic supply chains. These results have important implications for IT managers making SOA adoption decisions. Investment in SOA adoption is likely to prove more beneficial if the adopting firm has integrated most of its customers in its electronic supply chain. If the adopting firm has integrated most of its suppliers and partners in its electronic supply chain but not customers then SOA adoption may even prove

detrimental to electronic supply chain performance as it could draw resources away from beneficial customer oriented investments (20).

Table 11: Summary of Hypotheses Testing (20)

	Hypothesis	**Result**
1	SOA adoption leads to better electronic supply chain performance	Supported
2	SOA adoption increase firm's ability to leverage electronically integrated customers to achieve better electronic supply chain performance	Supported
3	SOA adoption increase firm's ability to leverage electronically integrated suppliers to achieve better electronic supply chain performance	Not Supported
4	SOA adoption increase firm's ability to leverage electronically integrated partners to achieve better electronic supply chain performance	Not Supported

The challenge in studying adoption of technology paradigms like SOA is in creating operational measures of the intangible benefits. An approach provided to measuring both the direct effect of SOA adoption and its mediating effect on firm's ability to leverage customer assets for better electronic supply chain performance. SOA adoption is most valuable when the firm uses this approach for architecting both its internal and external operations with a careful focus on integration with customer operations (20).

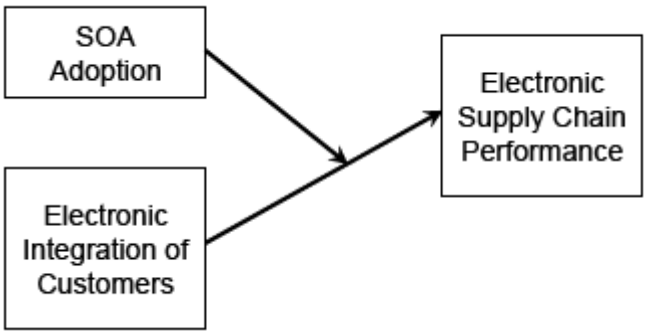


Figure 18: Causal Path/Mechanism of Impact of SOA Adoption on Electronic Supply Chain Performance (20)

5.2. Discussion of Parameter Changes

In previous section, the parameters that predicting positive changes according to presented approach are examined. How these parameters are determined and obtained, and causes of change are explained. This section is focused on the results of these changes. The results these changes cause, of the situations they prepared ground for and advantages will be highlighted.

Numerical analyses, applied hypothesis, or before/after comparison values show that, some positive changes occur through presented approach. These changes are like percent of customer or partners that included in e-SCM process, percent of followed business processes in e-SCM applications, average annual revenue of any firm that included in vendor network and chain count of product/manufacturer relationship.

The increase of business processes included e-SCM process is quite striking. Basically this is the most effective and most predisposing one for other positive changes. This change means, more process can be included to e-SCM process and more process can be executable with a controlled and central structure. Through easily obtaining to central and instant data by service oriented architecture, more comprehensive recording and following processes can be done. Not only a customer record to the system, but also visits to the firm, purchases vehicles, visit to maintenance service, pleasure surveys, phone calls, sent SMS messages etc. This is a versatile recording and evaluating system.

Similarly, lot of information can be stored and reported just like main category of business processes, subcategories of them, made of duration, labor performances. This detailed data holding provides detailed analyses. This data store is a result of increasing customer and business process count included in e-SCM.

Adoption of partner firms to the system can be explained as the same. So, it is easy to manage processes for the partner firms because of the authorization and communication between services provided by service oriented architecture. This situation fastens the processes with partner firms. Data inconsistencies prevented, and save money and time because there will be no longer one-to-one communication.

So, processes become shorter, human based mistakes decreased to low levels, planning will be make more trust worthy, and by the decreased level of these mistakes distributors and vendors gains more than before.

The other important thing is chain number changes which is explained on method. This change defines basically providing supply of a part from different suppliers, and making supply more different kinds of part from manufacturer. The bigger benefit of this change, mostly seen at distributor side. Distributor sees all orders of vendor network totally and evaluates them. So, they can estimate the rate of spare part- order for the future. The decrease on chain number provides the freedom of supplying spare parts from different manufacturers if demands on a spare part increases unexpectedly.

As the same, if there will be a problem at any process or with any manufacturer, these is freedom to make production at different manufactures and continue with them. So, production orders will not wait and money and time losses because of working with only one alternative will be prevented. Production orders can be separated inside the manufacturer network according to their intensities. So, the will be a big gaining from distributor to the customer of a vendor inside the vendor network because of the parallel processing.

5.3. Evaluation

As it is known, in this thesis project there are two different problems mentioned that are going to be solved. The first one is, all different locations in spare part supply chain have different systems for handling their own stocks. So, data inconsistency occurs between vendors and distributor and this causes time, labor and data losses. The other problem previously mentioned is, local stock planning processes are not made according to numerical data which are gaining from interpreted feedbacks. So, loss of time, money and customer satisfaction increases.

As mentioned in the first problem, if the stated situation is examined in detail there appears a striking result. If a location in large vendor network is taken it can be seen that processes with wrong stock code is not important. But if considered the large network as in our sample scenario data inconsistency causes effective money and time losses.

According to the data specified by the distributor, a sample cost calculation was made based on:

> Approximately 100 car sales point vendor network, more than 100 wholesale customer and other rings of supply chain considered. As a sector there always a problem for every 2 months in a year because of the spare part code inconsistencies of supply chain management.

This problem may occur at order phase, delivery phase, shipping phase, sales phase or after sales phase, and causes;

- Extra shipping for the right spare part.
- Shuttling to service or after sales point by end user
- Customer dissatisfactions and money loss
- Extra correspondences, procedures and correctness of processes and its causes labor losses.

When calculated, it means approximately $200.000 extra cost per year. Presented solution in this thesis project removes this problem; spare part code inconsistency

prevented by BizTalk Server which provides a strong central structure and SOA infrastructure.

If it is taken the other problem aimed to solve at the beginning in detail, it can be seen that planning local stocks of vendors is also important. Before the solution stock planning and dependent stock orders are made according to individual decisions of stock personnel. Sometimes this situation creates mistakes.

The solution presented is totally service oriented. All process steps modeled as service and included into the service structure. These services are dependent and integrated. So, there is a structure where services can communicate with each other. This result is provided by SOA infrastructure. Filtering any kind of movements of any stock card by any date interval, and making certain deductions according to this movement, also planning stock operations and the orders that purchased to main source, provides the most efficient way to operate the reserves while planning the stock movements. Thus, prevent congestion of the reserves, left over of a stock card that have much requests, correspondingly increasing shipment movements; customer loses because of delayed delivery time and the loss that based on all these causes.

As a result in this thesis project, BizTalk Server technology that constructs all application over, is mostly efficient on service oriented architecture for providing specifications like integrated user experiences on different applications. Applied model solution provides a substructure for integrating existing applications platform independently, creating, presenting and using new services. BizTalk Server is at the center of the SOA strategy and this SOA based solution applied successfully on spare part supplying process of related industry.

Collaboration in auto supply chain involves participation of multiple stakeholders across the supply chain towards sharing information at different levels of supply chain management activities. Traditional means of point to point application integration falls short of achieving the objective of collaboration and is not suited for agile business processes. SOA provides a new approach to address integration needs in auto supply chain management towards enabling collaboration.

An SOA based integration platform allows standards based integration of multiple types of interfaces that communicate using different data formats over different

protocols. Hence such a platform is ideally suited to handle seamless integration requirements in a collaborative supply chain.

6. CONCLUSION

Automotive industry has an important role in Turkish economy. Since there exists no base production, there are many distributors for different automotive brands. These distributors organize many sub processes like procurement from main source, distribution, service, after sales service. Spare part supply is the most important part of these processes and there is a heavy supply chain process which starts from main source and ends at domestic vendors and other automotive firms.

When the conditions and the environment of the automotive sector are studied, it has been observed that different software platforms are used by vendors which are located at different locations and this cause poor data synchronization of stock and results is loss of time, labor and data. Additionally, logistics, stock movements and local stock plan processes should be synchronized to coordinate with each other and work together as an integrated service background. This causes planning failures and loss of time, money and lack of customer satisfaction. As to summarize, general investigation shows that defected problems were poor data synchronization and planning failures. Due to the lack of synchronization and integration problems and the details were mentioned at the section 1.2. Similarly, being related each other warehouse planning, order planning, procurement and logistics planning deficiencies and problem caused by these situation are explained in section 2.5.

For the purpose of implementing Service Oriented Architecture (SOA) approach, considered processes and models of these processes with the perspective of SOA approach are presented clearly in the thesis. Also, a sample application presented which includes sub processes like ordering, stock, integration service, and database models for different roles.

When the general results of the solution are considered, it can be seen that identified problems of Supply Chain Management (SCM) of the automotive industry are resolved and the status is improved. By this solution, spare part supply sector may gain a modern approach which is based on Service Oriented Architecture and a complete solution presented to the sector covering all the SCM roles. These improvements are supported by the results as numerical analyses, comparisons and statistical survey data.

Suggested approach presents a solution model about how to design a central architecture, integration between different units, which data can be reached by which roles. Additional applications can be applied on the platform based on this solution model. For example, a database that will be integrated to current multiple database group structure and a new software application that compatible with existing service structure can be integrated easily. Administration of a never mentioned process in the thesis study may be performed simply.

Also, this approach can be a basis of a fully national work which includes planning, developing, applying and maintenance and support processes. With the support of a project with enough money and labor, this approach can be implemented and management of an important process for Turkey can be done with national fund and labor.

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8. APPENDIX

8.1. Technology Evaluation Center (TEC) Screenshots and Questions

8.1.1. Screenshots

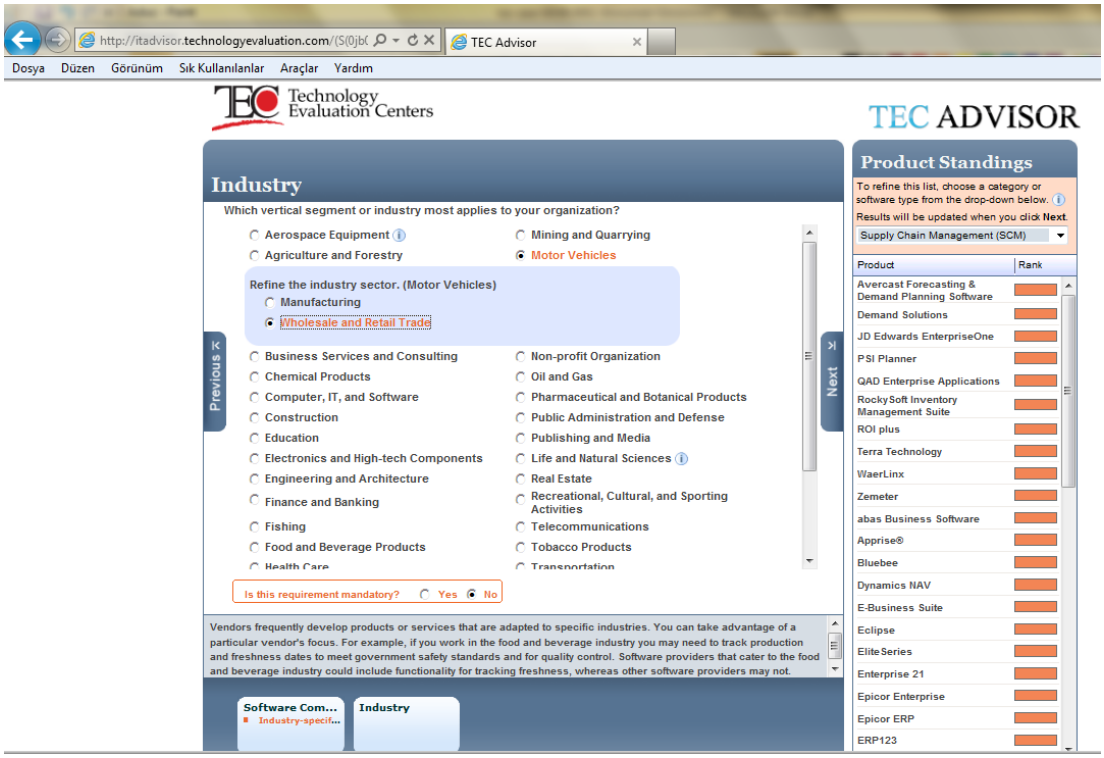

Figure 19: Industry Selection Screen

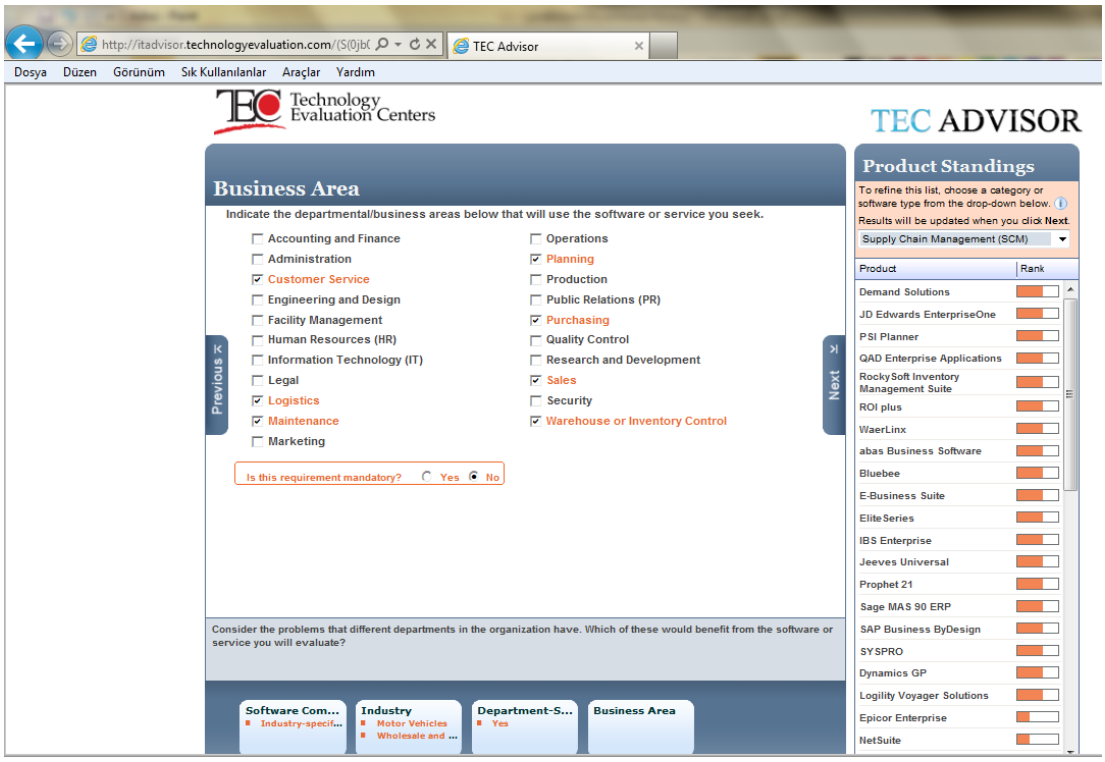

Figure 20: Business area Selection Screen

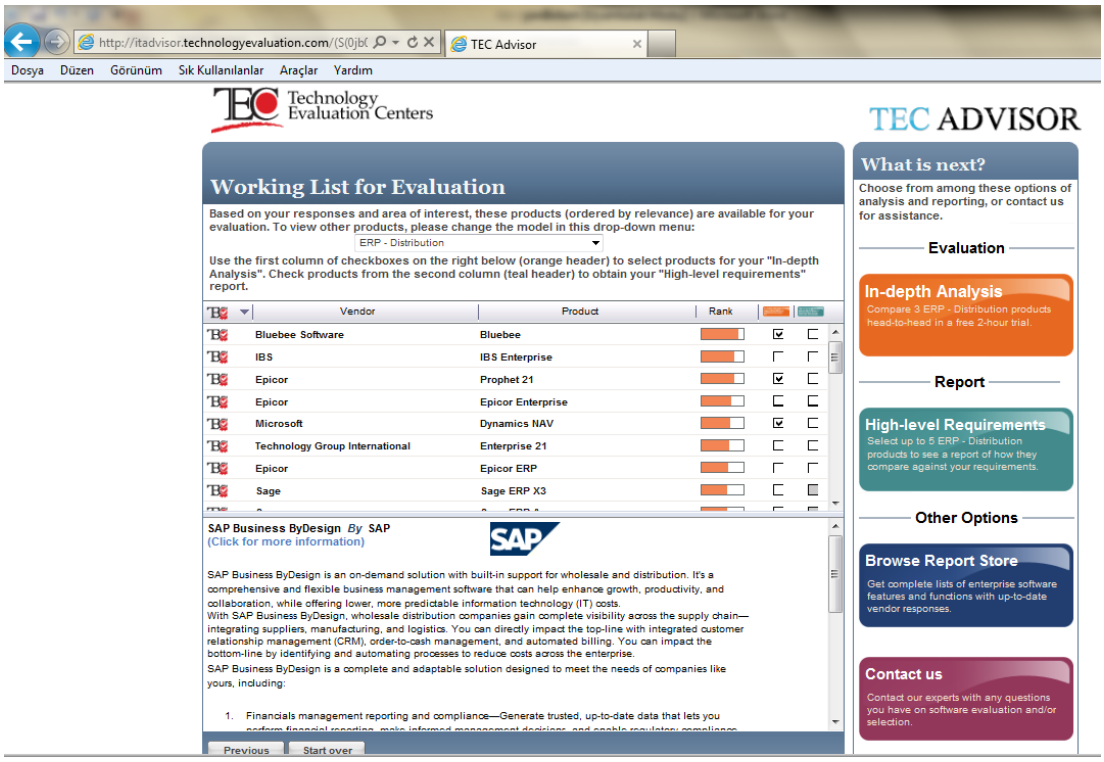

Figure 21: Solution Selection Screen

8.1.2. Questions

1) **Software Comparison:**

   Let us help you find the right products or services. Evaluate based on:

2) **Industry:**

   Which vertical segment or industry most applies to your organization?

3) **Department-Specific Needs:**

   Are there specific requirements for departments or business areas within your organization?

4) **Business Area:**

   Indicate the departmental/business areas below that will use the software or service you seek.

5) **Functionality by Business Area :**

   Based on your departmental specifications, the following functionality may be important for your needs.

6) **Local Support:**

   For which of the following regions do you require a local support presence?

7) **Language Support:**

   In which languages will the solution be used?

8) **Number of Employees:**

   How many people are employed throughout your entire organization?

9) **Other Considerations:**

   The following issues tend to be of a more technical nature. Select items you'd like to have a bearing on which products or services you evaluate.

10) **Annual Revenue:**

    What is your organization's annual revenue?

11) **Budget:**

    How much has your organization budgeted, in total, for this project?

8.2. Web Services

8.2.1. Order Listing Service

```
[WebMethod]
publicDataSet SiparisListele(int urunId, string siparisDurum, int ilgiliKullanici, int
ilgiliTedarikci, string firmaKod)
      {
DataSet ds = newDataSet();
string kurumDb = "";
string kurumTur = "";
string constr = ConfigurationManager.ConnectionStrings["conn"].ConnectionString;
SqlConnection baglanti = newSqlConnection(constr);

SqlCommand komut = newSqlCommand("select kurumTurKod,kurumDbKod from
kurum where kurumServisKod='" + firmaKod + "'", baglanti);
          baglanti.Open();
SqlDataAdapter daGiren = newSqlDataAdapter(komut);

DataTable dtGiren = newDataTable();

try
          {
             daGiren.Fill(dtGiren);
             kurumTur = dtGiren.Rows[0][0].ToString();
             kurumDb = dtGiren.Rows[0][1].ToString();
          }
catch (Exception ex)
          {
throw ex;
          }
          baglanti.Close();


string constr3 =
ConfigurationManager.ConnectionStrings[kurumDb].ConnectionString;
SqlConnection baglanti3 = newSqlConnection(constr3);
          baglanti3.Open();

string select3 = "select s.siparisId,s.siparisDurum,CASE(s.siparisTur) WHEN 'PR-
ALS' THEN 'ALIŞ SİPARİŞİ' WHEN 'PR-STS' THEN 'SATIŞ
SİPARİŞİ'END,s.siparisTarih,k.kullaniciAd,t.tedarikciAd from siparis s left outer
join kullanici k on s.siparisIlgiliKullaniciId=k.kullaniciId left outer join tedarikci t on
s.siparisIlgiliTedarikciId=t.tedarikciId WHERE 1=1";
if (urunId != 0)
          {
             select3 += " AND s.siparisId IN (SELECT siparisDetaySiparisId from
siparisDetay where siparisDetayUrunId='" + urunId + "')";
          }
```

```
if (siparisDurum != "")
        {
          select3 += " AND s.siparisDurum='" + siparisDurum + "'";
        }
if (ilgiliKullanici != 0)
        {
          select3 += " AND s.siparisIlgiliKullaniciId='" + ilgiliKullanici.ToString()
+ "'";
        }
if (ilgiliTedarikci != 0)
        {
          select3 += "AND s.siparisIlgiliTedarikciId='" + ilgiliTedarikci.ToString()
+ "'";
        }


SqlDataAdapter da3 = newSqlDataAdapter(select3, baglanti3);
        da3.Fill(ds);
return (ds);
      }
```

8.2.1.1. Screenshots of Order Listing Web Service

Figure 22: Order Listing Web Service

SOAP 1.1

```
POST /Service1.asmx HTTP/1.1
Host: localhost
Content-Type: text/xml; charset=utf-8
Content-Length: length
SOAPAction: "http://tempuri.org/StokBilgiGetir"

<?xml version="1.0" encoding="utf-8"?>
      <soap:Envelopexmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                     xmlns:xsd="http://www.w3.org/2001/XMLSchema"
                  xmlns:soap="http://schemas.xmlsoap.org/soap/envelope/">
<soap:Body>
<StokBilgiGetirxmlns="http://tempuri.org/">
<urunId>int</urunId>
<firmaKod>string</firmaKod>
</StokBilgiGetir>
</soap:Body>
</soap:Envelope>
HTTP/1.1 200 OK
Content-Type: text/xml; charset=utf-8
Content-Length: length

<?xml version="1.0" encoding="utf-8"?>
<soap:Envelopexmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:xsd="http://www.w3.org/2001/XMLSchema"
xmlns:soap="http://schemas.xmlsoap.org/soap/envelope/">
<soap:Body>
<StokBilgiGetirResponsexmlns="http://tempuri.org/">
<StokBilgiGetirResult>
<xsd:schema>schema</xsd:schema>xml</StokBilgiGetirResult>
</StokBilgiGetirResponse>
</soap:Body>
</soap:Envelope>
```

SOAP 1.2

```
POST /Service1.asmx HTTP/1.1
Host: localhost
Content-Type: application/soap+xml; charset=utf-8
Content-Length: length

<?xml version="1.0" encoding="utf-8"?>
<soap12:Envelopexmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:xsd="http://www.w3.org/2001/XMLSchema"
xmlns:soap12="http://www.w3.org/2003/05/soap-envelope">
<soap12:Body>
```

```
<StokBilgiGetirxmlns="http://tempuri.org/">
<urunId>int</urunId>
<firmaKod>string</firmaKod>
</StokBilgiGetir>
</soap12:Body>
</soap12:Envelope>
HTTP/1.1 200 OK
Content-Type: application/soap+xml; charset=utf-8
Content-Length: length

<?xml version="1.0" encoding="utf-8"?>
<soap12:Envelopexmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:xsd="http://www.w3.org/2001/XMLSchema"
xmlns:soap12="http://www.w3.org/2003/05/soap-envelope">
<soap12:Body>
<StokBilgiGetirResponsexmlns="http://tempuri.org/">
<StokBilgiGetirResult>
<xsd:schema>schema</xsd:schema>xml</StokBilgiGetirResult>
</StokBilgiGetirResponse>
</soap12:Body>
</soap12:Envelope>
```

HTTP POST

```
        POST /Service1.asmx/StokBilgiGetir HTTP/1.1
Host: localhost
Content-Type: application/x-www-form-urlencoded
Content-Length: length

urunId=string&firmaKod=string
HTTP/1.1 200 OK
Content-Type: text/xml; charset=utf-8
Content-Length: length

<?xml version="1.0" encoding="utf-8"?>
<DataSetxmlns="http://tempuri.org/">
<schema
xmlns="http://www.w3.org/2001/XMLSchema">schema</schema>xml</DataSet>
```

8.2.2. Order Detail Listing Service

```
[WebMethod]
publicDataSet SiparisDetayListele(int siparisId, string firmaKod)
      {
DataSet ds = newDataSet();
string kurumDb = "";
string kurumTur = "";
string constr = ConfigurationManager.ConnectionStrings["conn"].ConnectionString;
SqlConnection baglanti = newSqlConnection(constr);

SqlCommand komut = newSqlCommand("select kurumTurKod,kurumDbKod from
kurum where kurumServisKod='" + firmaKod + "'", baglanti);
          baglanti.Open();
SqlDataAdapter daGiren = newSqlDataAdapter(komut);

DataTable dtGiren = newDataTable();

try
          {
             daGiren.Fill(dtGiren);
             kurumTur = dtGiren.Rows[0][0].ToString();
             kurumDb = dtGiren.Rows[0][1].ToString();
          }
catch (Exception ex)
          {
throw ex;
          }
          baglanti.Close();


string constr3 =
ConfigurationManager.ConnectionStrings[kurumDb].ConnectionString;
SqlConnection baglanti3 = newSqlConnection(constr3);
          baglanti3.Open();

string select3 = "";
if (kurumTur == "TEDARIKCI")
          {
             select3 = "SELECT
u.stokKartiTanim,s.siparisTarih,sd.siparisDetayDurum,sd.siparisDetayMiktar from
siparisDetay sd inner join siparis s on sd.siparisDetaySiparisId=s.siparisId inner join
stokKarti u on sd.siparisDetayUrunId=u.stokKartiId WHERE
sd.siparisDetaySiparisId='"+ siparisId+"'";
          }
elseif (kurumTur == "PERAKENDECI")
          {
             select3 = "SELECT
u.stokKartiTanim,s.siparisTarih,sd.siparisDetayDurum,sd.siparisDetayMiktar from
siparisDetay sd inner join siparis s on sd.siparisDetaySiparisId=s.siparisId inner join
```

```
stokKarti u on sd.siparisDetayUrunId=u.stokKartiId WHERE
sd.siparisDetaySiparisId='" + siparisId + "'";
        }

SqlDataAdapter da3 = newSqlDataAdapter(select3, baglanti3);
        da3.Fill(ds);
        return (ds);}
```

8.2.3. Stock Movement Listing Service

```
[WebMethod]
publicDataSet StokHareketListele(int urunId, string firmaKod, string tur,string
kullanici,string tedarikci)
      {
DataSet ds = newDataSet();
string kurumDb = "";
string kurumTur = "";
string constr = ConfigurationManager.ConnectionStrings["conn"].ConnectionString;
SqlConnection baglanti = newSqlConnection(constr);

SqlCommand komut = newSqlCommand("select kurumTurKod,kurumDbKod from
kurum where kurumServisKod='" + firmaKod + "'", baglanti);
        baglanti.Open();
SqlDataAdapter daGiren = newSqlDataAdapter(komut);

DataTable dtGiren = newDataTable();

try
        {
           daGiren.Fill(dtGiren);
           kurumTur = dtGiren.Rows[0][0].ToString();
           kurumDb = dtGiren.Rows[0][1].ToString();
        }
catch (Exception ex)
        {
throw ex;
        }
        baglanti.Close();


string constr3 =
ConfigurationManager.ConnectionStrings[kurumDb].ConnectionString;
SqlConnection baglanti3 = newSqlConnection(constr3);
        baglanti3.Open();

string select3 = "select
s.stokHareketId,s.stokHareketMiktar,s.stokHareketTarih,s.stokHareketTur,
st.stokKartiTanim,k.kullaniciAd,t.tedarikciAd from stokHareket s inner join
stokKarti st on s.stokHareketUrunId=st.stokKartiId left outer join kullanici k on
```

```
s.stokHareketIlgiliKullaniciId=k.kullaniciId left outer join tedarikci t on
s.stokHareketIlgiliTedarikciId=t.tedarikciId WHERE 1=1";
if (urunId != 0)
        {
           select3 += " AND s.stokHareketUrunId='" + urunId + "'";
        }
if (tur != "")
        {
           select3 += " AND s.stokHareketTur='" + tur + "'";
        }
if (kullanici != "")
        {
           select3 += " AND s.stokHareketIlgiliKullaniciId='" + kullanici + "'";
        }
if (tedarikci != "")
        {
           select3 += " AND s.stokHareketIlgiliTedarikciId='" + tedarikci + "'";
        }

SqlDataAdapter da3 = newSqlDataAdapter(select3, baglanti3);
        da3.Fill(ds);
return (ds);
      }


   }
        }
```

8.2.4. Stock Information Service

```
[WebMethod]
publicDataSet StokBilgiGetir(int urunId, string firmaKod)
      {
DataSet ds = newDataSet();
string kurumDb = "";
string kurumTur = "";
string constr = ConfigurationManager.ConnectionStrings["conn"].ConnectionString;
SqlConnection baglanti = newSqlConnection(constr);

SqlCommand komut = newSqlCommand("select kurumTurKod,kurumDbKod from
kurum where kurumServisKod='" + firmaKod + "'", baglanti);
        baglanti.Open();
SqlDataAdapter daGiren = newSqlDataAdapter(komut);

DataTable dtGiren = newDataTable();

try
        {
           daGiren.Fill(dtGiren);
           kurumTur = dtGiren.Rows[0][0].ToString();
```

```
            kurumDb = dtGiren.Rows[0][1].ToString();
        }
catch (Exception ex)
        {
throw ex;
        }
        baglanti.Close();

switch (kurumTur)
        {
case"TEDARIKCI":
string constr2 =
ConfigurationManager.ConnectionStrings[kurumDb].ConnectionString;
SqlConnection baglanti2 = newSqlConnection(constr2);
                baglanti2.Open();
string select = "select td.stokKartiTanim AS TedarikciTanim,td.stokKod as
TedarikciKod,mr.stokKartiTanim as MerkezTanim,mr.stokKartiKod as MerkezKod
from tedarikci.dbo.stokKarti td inner join merkez.dbo.stokKarti mr on
td.stokKartiMerkezId=mr.stokKartiId";

if (urunId != 0)
                {
                   select += " where td.stokKartiId='" + urunId + "'";
                }

SqlDataAdapter da = newSqlDataAdapter(select, baglanti2);
                da.Fill(ds);

break;
case"PERAKENDECI":
string constr3 =
ConfigurationManager.ConnectionStrings[kurumDb].ConnectionString;
SqlConnection baglanti3 = newSqlConnection(constr3);
                baglanti3.Open();
string select3 = "select pr.stokKartiTanim AS PerakendeciTanim,pr.stokKod as
PerakendeciKod,mr.stokKartiTanim as MerkezTanim,mr.stokKartiKod as
MerkezKod from perakendeci.dbo.stokKarti pr inner join merkez.dbo.stokKarti mr
on pr.stokKartiMerkezId=mr.stokKartiId";

if (urunId != 0)
                {
                   select3 += " where pr.stokKartiId='" + urunId + "'";
                }

SqlDataAdapter da3 = newSqlDataAdapter(select3, baglanti3);
                da3.Fill(ds);

break;
default:
break;
```

```
        }
return (ds);
```

8.2.5. Stock Quantity Information Service

```
[WebMethod]
publicDataSet StokMiktarBilgiGetir(int urunId, string firmaKod)
      {
DataSet ds = newDataSet();
string kurumDb = "";
string kurumTur = "";
string constr = ConfigurationManager.ConnectionStrings["conn"].ConnectionString;
SqlConnection baglanti = newSqlConnection(constr);

SqlCommand komut = newSqlCommand("select kurumTurKod,kurumDbKod from
kurum where kurumServisKod='" + firmaKod + "'", baglanti);
        baglanti.Open();
SqlDataAdapter daGiren = newSqlDataAdapter(komut);

DataTable dtGiren = newDataTable();

try
        {
           daGiren.Fill(dtGiren);
           kurumTur = dtGiren.Rows[0][0].ToString();
           kurumDb = dtGiren.Rows[0][1].ToString();
        }
catch (Exception ex)
        {
throw ex;
        }
        baglanti.Close();

switch (kurumTur)
        {
case"TEDARIKCI":
string constr2 =
ConfigurationManager.ConnectionStrings[kurumDb].ConnectionString;
SqlConnection baglanti2 = newSqlConnection(constr2);
                baglanti2.Open();
string select = "select stokKartiTanim,stokAnlikMiktar,stokKod from stokKarti";

if (urunId != 0)
                {
                   select += " where stokKartiId='" + urunId + "'";
                }

SqlDataAdapter da = newSqlDataAdapter(select, baglanti2);
                da.Fill(ds);
```

```
break;
case"PERAKENDECI":
string constr3 =
ConfigurationManager.ConnectionStrings[kurumDb].ConnectionString;
SqlConnection baglanti3 = newSqlConnection(constr3);
                baglanti3.Open();
string select3 = "select stokKartiTanim,stokKod,stokAnlikMiktar from stokKarti";

if (urunId != 0)
                {
                   select3 += " where stokKartiId='" + urunId + "'";
                }

SqlDataAdapter da3 = newSqlDataAdapter(select3, baglanti3);
                da3.Fill(ds);

break;
default:
break;

          }
return (ds);
```

8.3. Database

8.3.1. Supplier & Central Database Diagrams

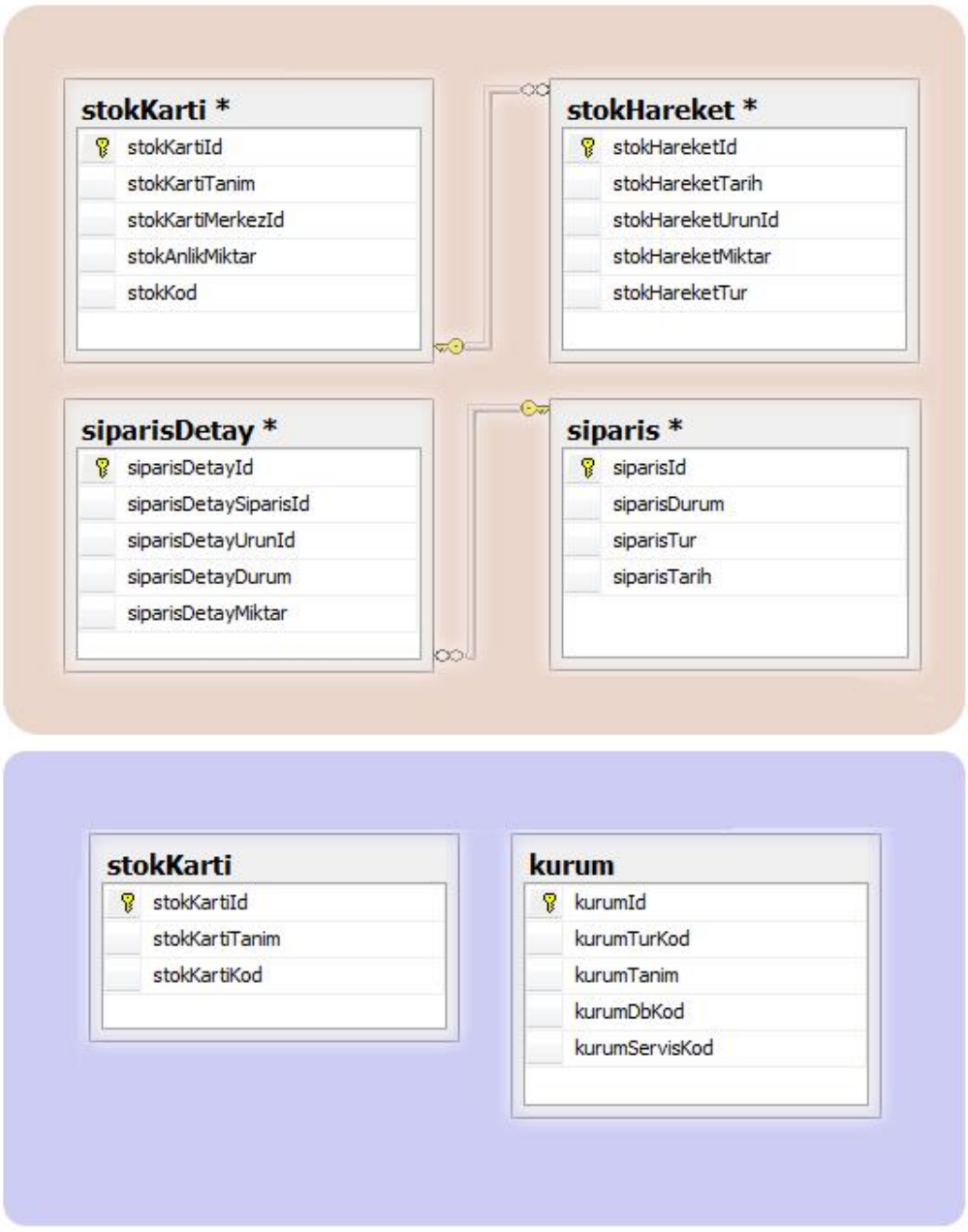

Figure 23: Supplier and Central Database Diagrams

8.3.2. Retailer Database Diagram

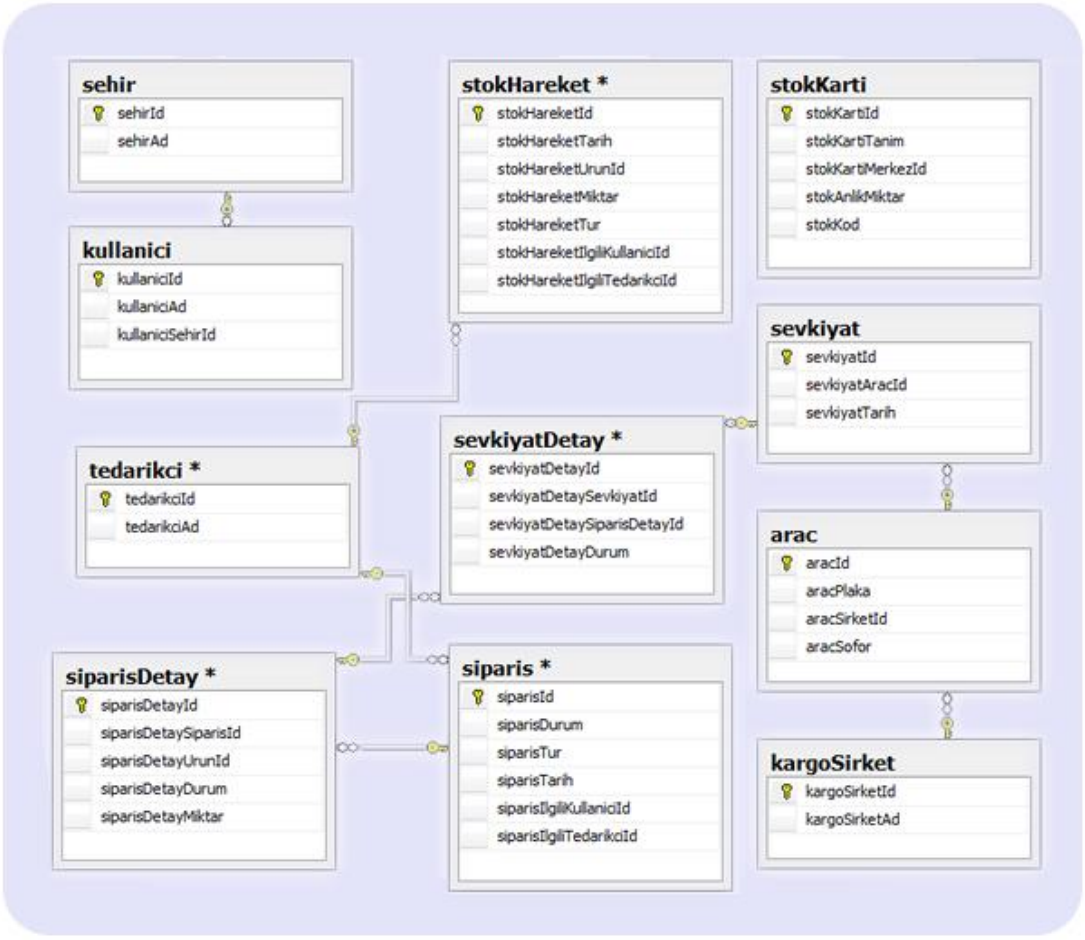

Figure 24: Retailer Database Diagram

8.4. Calculations

Table 12: Summary Statistics of Variables

Variable	No of Observations	Mean	Standard Deviation	Minimum	Maximum
Electronic Supply Chain Effectiveness	388	26.64	30.89	0	100
Electronic Integration of Customers	388	37.06	34.85	0	100
Electronic Integration of Suppliers	388	40.96	33.74	0	100
Electronic Integration of Partners	388	37.02	37.12	0	100
SOA Adoption	388	0.75	0.44	0	1
Firm Size	388	8260.58	15403.28	1000	186763
Industry	388	0.53	0.50	0	1

Table 13: Correlation of Variables

	ESupChainEff	ElecCust	ElecSup	ElecPart	DSOA	FirmSize
Electronic Integration of Customers	0.58	1.00				
Electronic Integration of Suppliers	0.18	0.34	1.00			
Electronic Integration of Partners	0.39	0.51	0.51	1.00		
SOA Adoption	0.15	0.06	0.09	0.18	1.00	
Firm Size	0.18	0.14	0.16	0.17	0.08	1.00
Industry	(0.07)	(0.06)	0.10	0.04	0.01	0.10

Table 14: Results of the OLS Regression with Robust Standard Errors (20)

	Model 1	Model 2	Model 3	Model 4
Electronic integration of customers	**0.457** ***	**0.322** ***	**0.461** ***	**0.460** ***
p-value	0.000	0.000	0.000	0.000
Electronic integration of suppliers	**-0.082** *	-0.076	**-0.151** *	**-0.083** *
p-value	0.083	0.112	0.075	0.082
Electronic integration of partners	**0.120** **	**0.117** **	**0.116** **	0.018
p-value	0.021	0.023	0.028	0.854
SOA adoption	**6.800** **	0.659	3.355	3.152
p-value	0.014	0.823	0.361	0.283
Firm size	**0.0002** ***	**0.0002** **	**0.0002** ***	**0.0002** ***
p-value	0.005	0.011	0.008	0.006
Industry	-2.889	-2.820	-2.736	-2.865
p-value	0.269	0.279	0.300	0.274
(SOA adoption) * (Electronic Interation with customers)		**0.178** *		
p-value		0.054		
(SOA adoption) * (Electronic Interation with suppliers)			0.094	
p-value			0.338	
(SOA adoption) * (Electronic Interation with partners)				0.128
p-value				0.194
N	388	388	388	388
Prob > F	0.0000 ***	0.0000 ***	0.0000	0.0000
R-Square	0.3734	0.3808	0.3753	0.3772

Note: * Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level