“Supply Chain Risk Management with a Focus on Formalization Concepts for Strategic Procurement Processes”

Von der Fakultät für Ingenieurwissenschaften,
Abteilung Maschinenbau und Verfahrenstechnik der
Universität Duisburg-Essen
zur Erlangung des akademischen Grades

eines

Doktors der Ingenieurwissenschaften

Dr.-Ing.

genehmigte Dissertation

von

Mian Wasim Layaq

Aus

Swat-PK

Gutachter 1: Univ.-Prof. Dr.-Ing. Bernd Noche
Gutachter 2: Univ.-Prof. Dr.-Ing. Frank Lobeck

Tag der mündlichen Prüfung: 04.08.2022

Abstract

With the current growth in technology, the world has become a global home rather than a global village, and in this race of globalization, all the firms have the common goals of saving cost, grabbing more customers, and leading the business market. The digital revolution is already knocking at our doors, the world is going towards digitization of processes; concepts like Industry 4.0, IoT, Blockchain Technology and Procurement 4.0 are floating around. Companies cannot survive in the industry all alone and rather, collaboration and cooperation are the need of time, because of which the supply chain are becoming more complex than ever which makes the supply chain more prone to risks.

Supply chains of today are more vulnerable than in the past due to the growing globalization, many companies manufacture and source products internationally, which leads to different risks in the supply chain, these risks need to be identified and mitigated properly. Blockchain technology can be used as a risk mitigation tool by integrating its basic features, like data storage and retrieval in supply chain because of which the automation of processes would mitigate risks and improve performance of supply chain. With the implementation of Blockchain Technology in a supply chain, the overall performance of supply chain can be improved in terms of visibility, traceability, demand forecasting, access of information etc., which will reduce the risks associated.

The digital revolution currently is affecting every sector of the business, prominently hitting the supply chain industry and as procurement is a vital part of supply chain, automatically, this impact will be shifted to the procurement industry as well.

If supply chain is considered as the vein of any organization, procurement is then the injection point of the right material to flow in the vein to keep it running. Procurement is an important part of the supply chain and the value it could bring to any supply chain should not be under-estimated; it involves collaboration between many parties due to which the impact of digital revolution is also hitting the procurement industry and is making the procurement processes prone to risks.

Procurement is divided into 3 levels i.e., Strategic Procurement, Tactical Procurement and Operational Procurement.

Strategic Procurement is the most important procurement type and is also known as P2S (Plan to Strategy), it refers to long term organization-wide plans to ensure timely supply of goods and services which are crucial and critical for the business. Moreover, it also focuses on organizational spends, consolidation of suppliers, identifying critical and strategic suppliers, and maintaining long term relationships with strategic suppliers.

Tactical Procurement also known as S2C (Source to Contract) refers to the short-term plans up to 1 year and transactional activities to keep the business running smoothly which starts from the requirement identification and ends with a complete contract with suppliers.

Operational Procurement also known as P2P (Procure to Pay) or R2P (Requisition to Pay) refers to the process of requisitioning, purchasing, receiving, and paying for the good or services needed; this process is the actual purchasing process of the procurement.

The objective of this research is to show, analyse and investigate how the supply chain risks can be managed effectively, what are risks associated with the procurement processes and how automation of all the procurement processes will improve the overall performance of procurement. Risk management is all about identifying, analysing, evaluating, and mitigating possible risks, which could affect the business processes.

Emerging literature, case studies, blogs, expert opinions, market knowledge, practical business experiences, supplier evaluation techniques like weighted point method and simulation concepts like monte carlo simulation are used to fulfil this task. This research can contribute to explore further research on automation of all procurement processes e.g., SRM, spend management, claim management etc. and as well as on the usage of Blockchain Technology in the FMCG supply chain. In a nutshell the proposed concepts in this research could be used as a base to create a one-stop-solution that can address all the problems and fulfil all the requirements of an organization.

Key words: Digitization, Automation, Industry 4.0, Supply Chain Risks, Supply Chain Risk Management, Blockchain, Procurement, Procurement 4.0, P2S, S2C, P2P, Monte Carlo Simulation, Weighted Point Method, Supplier Relationship Management (SRM), One-Stop-Solution, Strategic Procurement, Tactical Procurement, Operational Procurement, Spend Management

DEDICATION

To the pillars of my life

Allah Almighty, Prophet Mohammad (P.B.U.H), my Parents, my Brothers and Sister, my Grandmother, my Sisters in Law, my Nephews, my Wife and Kids (Zala, Wisam, Waqif, and Zaira)

Without you all, my life would fall apart.

Sometimes I do not know where the life's road will take me,

Nevertheless, then the continuous blessings of Allah give me a wonderful path forward and strength which is always the best I can have.

Baba Jan, it is your faith in me and with your love, support, and prayers this is happening, I look forward to your prayers for more.

Ami, you have given me immense strength of believing in myself. It would have not been possible without your prayers and thanks for teaching me that I should never give up. I wish you would have been with us to witness this, but I am sure you can see it. **I miss you Ami.**

Khatera, without your support and love it would have not been possible.

We did it….

Acknowledgements

I am grateful to Professor. Dr. Ing. Noche for providing me with the opportunity to explore the world of supply chain management and procurement. I would like to thank him for giving his precious time, motivation, and encouragement whenever I needed.

I would like to express my deepest gratitude to Mr. Dr. Ing. Alexandar Goudz for the unlimited support, positive comments, encouragement, and engagement through the learning process of this thesis wherein I learnt a lot.

I would like to thank my mentors Mr. Lutz Wagner, Mr. Andreas Pohle and Mrs. Silvia Remer who introduced me to explore the world of supply chain management and procurement and gave me the confidence to achieve my goals without any fear and supported me immensely where I needed them.

I would also extend my thanks to my friends Mr. Dr. Shahid Mohammad, Mr. Dr. Mohammad Sajid, Mr. Dr. Mohammad Salim, Mr. Farid Khan, Mr. Abbas Akhundzada, Mr. Karim Baidar, Mr. Mohammad Atif, Mr. Azeem Javed, Mr. Majid Iqbal Khattak, Mr. Shoaib Mohammad, Mr. Noorsaied Ahmadzai and all my loved ones, who have supported me throughout this entire process. I will be grateful for your love forever.

Special thanks to the Department of Transport and Logistics University of Duisburg-Essen for providing me with an opportunity to be a researcher of such a great and unforgettable Department, I will always remember the time I spent here.

List of Figures:

List of Tables

List of Abbreviations

SCM	*Supply chain management*
SCRM	*Supply chain risk management*
CRM	*Customer relationship management*
SRM	*Supplier relationship management*
IoT	*Internet of things*
PO	*Purchase order*
ROI	*Return on investment*
KPI	*Key performance indicator*
FMCG	*Fast moving containerized goods*
CAPEX	*Capital expenditure*
OPEX	*Operational expenditure*
EBIT	*Earnings before interest and taxes*
P2P	*Procure to pay*
S2C	*Source to contract*
P2S	*Plan to strategy*
JIT	*Just in time*
RFID	*Radio frequency identification*
R&D	*Research and development*
PQQ	*Pre-qualification Questionnaire*
HSE	*Health, Safety and Environment*
SLA	*Service level agreement*
AI	*Artificial intelligence*
WPM	*Weighted point method*

TCO	*Total cost of ownership*
T&C	*Terms and conditions*
FMEA	*Failure Modes and Effects Analysis*

Supporting documents - Annexes

- Supplier PQQ Template –ANNEX1.
- 100 Critical suppliers-ANNEX2.
- Evaluation Classification, Supplier Reports_ANNEX3

Clarifications

The basic goal of this page is to ensure that the readers understand the context of the following words used in this research.

Automation:

The word automation is used widely and is often connected to the Artificial Intelligence terminologies; typically, the word automation is used with machines or processes replacing human actions. But in the context of this research, the word automation does not mean execution of processes without human interactions, rather it means process with lesser human interactions. The goal is to automate the processes to a certain level, where efficient and effective reports, analysis are generated with lesser human interactions.

Procurement:

The word Procurement is often mixed with Purchasing and people use both these words for the same meaning. However, in the context of this research procurement is not only purchasing, but also more than that and it includes processes like SRM, Spend management, Contract management etc. Purchasing is just a small part of procurement; this topic is further elaborated in chapter 3.

Clarification:

Most of the content of this research has already been published in different international SCM and Procurement journals and conferences under my name. I am the first author of all these publications. Below are the citations and the full references are mentioned in the references section.

1. (Layaq, 2019)
    - Blockchain Technology as a Risk Mitigation Tool in Supply Chain
2. (Layaq, 2019)
    - The impact of digitization on tactical procurement and its risk management
3. (Layaq, 2019)
    - Empowering End-User by Risk mitigation concepts in operational procurement through digitization
4. (Layaq, 2020)
    - Monte Carlo Simulation Concept for Demand Risk Identification in a Supply Chain
5. (Layaq, 2020)
    - Risk mitigation strategy for spend management in strategic procurement through automation of processes
6. (Layaq, 2020)
    - Risk mitigation strategy to eliminate risks associated with claim management in operational procurement through automation

Table of Content

Chapter 1

Introduction

- Background for my research
- Complex supply chains of today
- Inter-organizational collaboration in supply chain
- Digital technologies of today
- Research objective and research questions

Chapter 2

Supply Chain Risk Management

- Introduction to supply chain risk management
- General framework of SCRM
- Understanding supply chain risks
- SCRM management process

Chapter 3

Deep Dive in Procurement

- Procurement definitions
- Differentiating between procurement and purchasing – clearing the misconceptions
- Understanding types of procurement
- Importance of procurement in SCM
- Procurement value contribution in organizational success
- KPI's related to procurement

Chapter 4

Blockchain Based Supply Chain

- Understanding blockchain technology, its types, terminologies, and applications
- Blockchain in supply chain
- Proposing a blockchain based supply chain concept
- Benefits of the proposed concept

Chapter 5

Automation of Operational Procurement (P2P)

- Explanation of the operational procurement execution cycles
- Risks associated with traditional operational procurement
- Proposing automation concept for operational procurement
- Benefits of the proposed concept over the manual processes

Chapter 6

Automation of Tactical Procurement

- Identifying the risks associated with tactical procurement
- Explanation of traditional tactical procurement execution cycles
- Risks within the traditional tactical procurement process
- Proposing automation concept for tactical procurement
- Benefits of the proposed concept against the traditional concept

Chapter 7

Automation of Spend Management Process

- Understanding strategic procurement in detail
- Explanation of spend management and its importance
- Explaining risks of uncontrolled spend management process
- Proposing automation concept for spend management
- Identifying spend management KPI's and performing experiments
- Benefits of the proposed automated solution

Chapter 8

Claim Management Automation Concept Embedded with P2P

- Understanding the importance of P2P in claim management
- Conventional claim management execution process
- Risks associated with the conventional processes
- Proposing automation concept to mitigate the risks
- Benefits of the proposed solution

Chapter 9

Automation Concept for Supplier Management Process

- Explanation of supplier relationship process and sourcing strategies
- Defining the risks associated in supplier management
- Explaining conventional supplier selection process
- Proposing automated conception for supplier selection process Monte carlo simulation
- Proposing Automated supplier evaluation concept
- Benefits of the proposed solution
- Experiments

Chapter 10

Automated Risk Mitigation Concept in Demand Management

- Explaining demand management and its importance in supply chain management
- Identifying supply chain risks impacting demand
- Proposing Monte carlo simulation concept to address the risks
- Benefits of the proposed solution
- Simulation experiments

Chapter 11

Conclusion

- Thesis Conclusion
- Proposing one stop software solution to address procurement types
- Key findings
- Limitation of the research
- Future work

Chapter 1: Introduction

The digital revolution is already knocking at our doors. With the fast growth in technology, the supply chains have become complex, making it challenging and prone to risks, but the digital era also gives us the edge to do complex things faster. The terms like “Industry 4.0” and “IoT” are hot topics these days and many believe that the supply chains and other industries must be ready to avoid the risks of going out from the race of new era, but the companies must invest in the right technologies, people, and processes in order to get the utmost advantages (Goyal, 2018).

This digital revolution has an impact on almost every part of the business making it prone to different risks. It has a greater impact on the supply chain industry and as procurement is a vital part of supply chain, automatically the impact will hit the procurement part as well and will make supply chain more prone to risks. Thus, these complexities have made the procurement processes, time consuming and very costly. If supply chain is considered as the vein of any organization, procurement is then the injection point of the right material to flow in the vein to keep it running.

The world is changing rapidly, the companies cannot survive in the industry all alone. Collaboration and cooperation are the need of time and because of these the supply chains are becoming more complex than ever and prone to risks. Disturbances and disruption can occur anytime and to anyone, but it does not mean that it is the end of the world, but rather when there is a difficulty there is always a way out. Traditionally risk management is all about identifying, analysing, evaluating, and mitigating possible risks, which could affect the business processes. Different strategies and concepts are used to minimize and mitigate risks.

Procurement is an important part of the supply chain, and it involves collaboration between many parties, it is divided into 3 levels i.e., Operational Procurement, Tactical Procurement and Strategic Procurement. The focus of the research is to dive deep into the procurement processes and to analyse what are the risks associated with the procurement processes, how huge the impact of this risk can be to any organization and what could be possible risk mitigation strategies to deal with these risks.

1.1 Background

Just like the above day-to-day examples, similar stories happen in supply chains as well. There have been many incidents in the supply chain businesses as well, which brought the businesses to the brink of bankruptcies which were the result of either wrong supplier selection and management, wrong procurement concepts, wrong spend management processes, natural disasters, geopolitical factors, or currencies fluctuations. Depending on their distinct risk management policies all these businesses responded to the risk in different ways, below are some examples.

I. The Ericsson's Crisis in 2000

One of the most important incidents in the history of risk management which worked as a wakeup call for many companies to take their risk management more seriously was the Ericsson crisis of 2000. On March 17, 2000, a power line in Albuquerque, New Mexico was hit by lightning. This strike caused a massive surge in the surrounding electrical grid, which turned

into a fire at a local plant owned by Royal Philips Electronics, damaging millions of microchips (Chopra, 2004).

Ericsson was using a single supply source policy and all their chips were being ordered from the same supplier 'Royal Philips Electronics'. This fire incident in its chip's suppliers disrupted their entire supply of chips material flow and as they were using single supply source so their whole supply chain was disturbed in a very short span of time, due to this incident Ericsson's loss was estimated to reach USD 400 million for its T28 model (Jansson, 2004). While on the other hand Nokia was also using the same Chip's supplier as one of its Chip's suppliers for its Business, but Nokia was using a multiple-supplier strategy, so Nokia's production suffered little during the crisis (Chopra, 2004). Soon after this incident Nokia immediately managed to switch to back up sources and escaped from this disastrous situation.

This plan of using multi-supplier strategy and the step forward of switching immediately to the backup suppliers eventually resulted in an increase of about 30% market share (Sheffi, 2005).

II. The Earthquake and Tsunami in Japan

In March 2011 a devastating earthquake took place in Tohoku Japan which was then followed by tsunami, this disastrous situation showed that how a single event of disruption can disturb many elements of global supply chains, including supply, distribution, and communications (SCRLC, 2011). This earthquake and Tsunami represented one of the costliest natural disasters on record, wreaking some US$235 billion worth of damage, according to World Bank estimates (Park, 2013).

III. The Taiwan Earthquake

Another example, which disrupted one of the most important elements (Information) of the supply chain, is the Taiwan earthquake in December 2006; this earthquake resulted in a breakage in the undersea cables of internet and slowed down the internet. An immediate aftermath of this disaster was a prolonged waiting time of containers in the Shanghai port in China because all procedures there were dependent on information systems (Nurmaya, 2012).

IV. The Earthquake at Port Town of Kobe Japan

An earthquake hit the port town of Kobe Japan in 1995, which resulted in destroying around 100,000 buildings. The aftermath of this disaster resulted in shutting down the largest port of Japan for 26 months. This disaster forced 1,000s of different Business firms to change their production, distribution, and inventory strategies for survival. Two biggest market players Procter & Gamble and Texas Instruments had to move their headquarters. But the worst part was that four major automotive companies had to stop production of more than 50,000 vehicles because there were no parts available due to this massive disaster (Menoni, 2001).

V. Wrong Procurement

One of the most intersting and expensive blunder in the history of procurment was, when the french state-control operation SNCF ordered 1860 new trains that were too wide for 1300 regional stations for which France had to pay $20 billion. The SNCF was forced to modify more than 1000 train stations, but at the first place it had already costed SNCF more $68,4 million (BBC, 2014), (Rich, 2014).

VI. Horse Meat Scandal – Poor Supplier Management

In 2013 one of the most reported incident was the horse meat scandal. Tesco which is one of the leading value chain super market in the UK was selling a product spaghetti Bolognese as a beef product, while in the reality it contained 60% of horse meat labelled as beef. The parliament was involved and many tests took place where it was confirmed that the product contained horse meat. Tesco confirmed and blamed one of its suppliers “Silvercrest” for the crisis (Stones, 2013). After this incident Tesco dropped its meat supplier over a “breach of trust” (Hodge, 2013). Blaming a supplier is not the solution of such incident, infact the root problem of this incident was a poor supply chain risk management and supplier management process used by Tesco. As a result of this incident Tesco lost its customer trust and it’s market shares were down by 1%, which equalled nearly 300m GBP of market value (Fletcher, 2013).

VII. Huawei & the USA Problems

Before the COVID-19 crisis, one of the major highlighted incidents of 2019 was the US ban on Huawei, where the US authorities black-listed and banned Huawei products.

Huawei is one of the largest telecommunication companies in the world with immense growth in 2019 and in the start of 2019, the company was predicted to become the world’s largest smartphone manufacturer, but because of this ban, Huawei was not able to do business with companies like Google, Intel, and many others (Brown, 2021). That is how it lost a lot of its market cap in terms of revenue.

VIII. Political Impact

There have been many incidents in the past but the most recent is the “Brexit topic” which is still hot and ongoing, but it is already having an impact on businesses across Europe. Many researchers believe that majority of organizations, which operate with the UK, will observe an overall costs increase in their businesses due to new tariffs, capital costs, and increasing labor costs etc. The Brexit process needs a deeper understanding of your entire supply chain to control costs and ensure supply (Smith, 2019). Further to this the clash between Huawei and the US government is also a vital issue faced by the supply chain in recent years.

IX. Currency Exchange Fluctuation

In business envoirnments, the currency fluctuation happens to be an ongoing topic, that can be the outcome of many issues. In February 2019 the value of pound has decreased almost 2% against the USD, besides this within just seven days, an increase of 3,5% in dollar-based commodities has observed. On the other hand, if the UK leave the EU, a potential 15% to 20% fall in the value of pound can be observed (Thornton, 2019). "In June 2008, Volvo Cars reported a 28% reduction in sales compared with the same period in previous year, with the biggest loss of about 50% in its SUVs. Fredrik Arp, the then CEO of Volvo Cars stated, “The weak dollar reduces the revenue, and it will further reduce the opportunities for R&D” (Nurmaya, 2012). All the elements / components of the supply chains are linked in such a way that if any of the element / components of the supply chain is disrupted, the whole supply chain directly or indirectly gets affected. An early researcher (Buzacott, 1971) stated in one of his reports "Any hiccup within the supply chain will cause delays and even disruption".

X. Covid-19 – Corona Crisis

The most recent and the most damaging one is the Covid-19 crisis. The COVID-19 crisis put the capabilities of the risk managers to test. Since December 2019 because of the corona crisis the world has changed dramatically, no one anticipated a pandemic in 21st century where the technologies are at the peak and that is why no one was ready to face the situation. The impact of the crisis is still enormous on every part of the supply chain, supply shortages, border closures, port closures, airports closures and many more, which are still suffering. During the beginning of the global outbreak in March, supply chains have had major problems to cope with an unpredicted demand for certain products when simultaneous restrictions for travel and production have been enforced and is still struggling to recover from this (Mazareanu, 2021).

Procurement is at the heart of the COVID-19 crisis' management and has taken an active role in mitigating the immediate impact of the pandemic. Now, as companies prepare for the crisis' long-term impact, a clear shift in mind-set is needed. Since the COVID-19 pandemic began battering the world, procurement professionals of almost every company have been rethinking their supply risk management capabilities. Most are grappling with little else today, as they try to figure out how best to cope with the current and lasting effects of the crisis (Thill, 2020).

Risk managers almost in every industry were not prepared for it. Businesses are trying to adapt to the new norm, but it is certain that they will face challenges even after the pandemic is over. However, the companies that started working on their risk management process at the time when Covid-19 was budding and took immediate actions to shift the productions from China to other sites in the first wave, somehow managed to avoid the utter imbalance in their businesses. The second wave changed the whole ball game. The IT Hardware industry took the maximum benefit out of the crisis, as most of employers in different sectors of the businesses allowed homes offices, distance learning in schools, which increased the demand of the IT-HW gadgets and that is how the prices started skyrocketing.

1.2 Explanation

From the above examples it is clear and obvious that any procurement, material, natural, financial, political or information risk can result in huge disruption in the supply chain, but if the risks are identified well on time, risk mitigation strategies can be implemented to eliminate or reduce the impact of the risks.

In above-mentioned scenarios, because of a fire incident to the Ericson's supplier, the material flow in the Ericsson supply chain was disrupted, which eventually affected the financial flow, so the whole supply chain was disturbed, and all this finally resulted in a disaster for Ericsson. In the other cases the disruption started because of a natural disaster, which affected the information flow which resulted into the disruption of port operations. This disruption of the port operations resulted in the disruption of the material flow which ended in a disruption in the financial flow and at last the entire supply chain was collapsed. The above-mentioned scenarios also show how the wrong procurement, political impact, and currency fluctuations can cause a huge damage to organizations. All this means that when any part of the supply chain is disrupted by any risk, the complete supply chain is affected. When the supply chain is affected, automatically the end customer is affected and the customer satisfaction is on stake, and when there is no customer satisfaction, the number of customers is reduced, and they switch to other companies that finally triggers immense losses in businesses.

The above-mentioned examples are a few from numerous vital disruptions, which have affected the supply chain industry in the last decade. "An overwhelming majority of companies surveyed, 83% consider supply chain disruptions to be a "moderate" to "greatest risk" overall considering all of the factors that can affect the financial well- being of their organizations." (Douvas, 2011). Whereas, the fact is that there are dozens of examples of risk management failure that the history of bussiness and supply chain industry holds.

Due to the increasing number of disruptions in supply chain, the researchers are showing interest in the research studies about the supply chain disruptions resulted from procurement, natural disasters, political and economic instability, volatile market dynamics or human actions and it has shown that supply chain risk issues are becoming new areas of focus in the supply chain operations (Berger, 2003), (Christopher, 2004), (Jansson, 2004), (Ritchie, 2007).

In this regard "Gartner Inc.", which is one the world's leading information technology research and advisory company has arranged a series of analyses where they have predicted the supply chain for coming years. According to these analyses, "Gartner Inc." has indicated there would be a vital increase in the employees in firms who will be only focusing on the risk management for the organizations, so much so, that even departments for exclusive risks management will be formed. The same study has also shown an intensified emphasis on the scalable risk assessment and management and utilizing advanced technologies to properly manage the diverse supply chain activities.

Further these analyses show that "By 2016, companies will revisit their low-cost country sourcing decisions, evolve their talent needs and build a core competency in predictive analytics to sense demand and supply, and manage risk" (Gartner, 2011). Indeed, they were right because in 2019 many businesses were focusing on the risk management related to procurement and supply chain management and were really investing into this area. Some well-known companies like DHL have opened their own risk management division called “Resilience360”, which not only takes care of the internal DHL risk management but also are selling their risk management solutions to other companies, they claim that the resilience360 predicts assess and mitigate risks with near real-time global visibility (Resilience, 2019).

The risks associated with supply chain are increasing day by day, but the important point for any organization would be to identify the risk areas well on time in order to cope up with the unlikely situation. From the disruption cases associated with supply chain presented above and many more available in different literatures, it is important to know what causes the vulnerabilities in supply chain and how to ensure its resilience. The background above provides a base for the motivation of exploring the type of risks and how they can affect the supply chain operations. In chapter 2 of this research, the possible risks which can cause disruption to the supply chain will be presented.

1.3 Complex Supply Chain

The managers of the supply chains must take care of many things at the same time. Figure 1.1 shows blink of the complexity of supply chains of today and future.

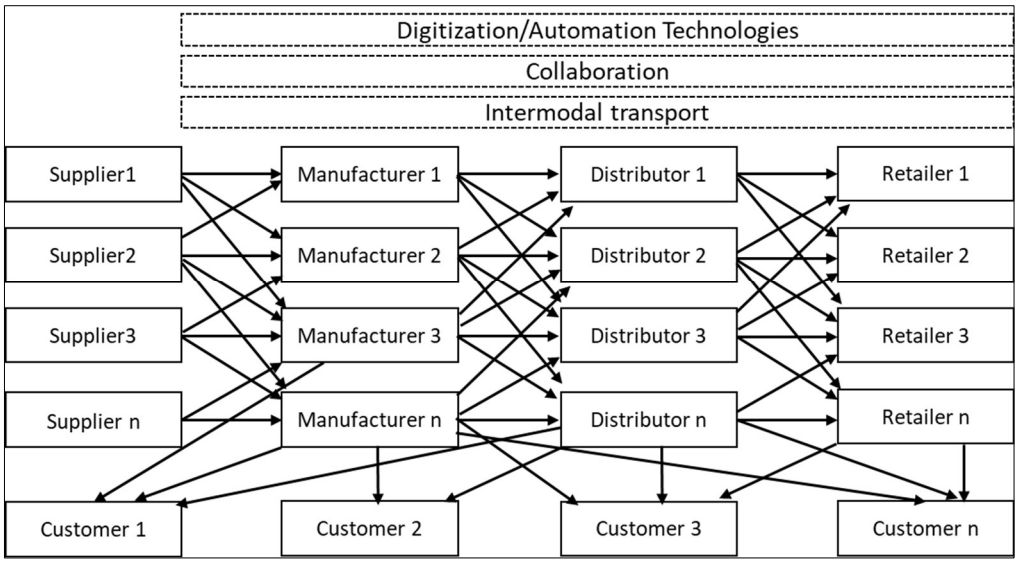


Figure 1.1. Complex supply chain of today: figure based on (Mishra, 2015) *with modifications*

Many manufacturers in today's world own different manufacturing sites where different types of products are manufactured. The manufactured products are sent to their warehouses; these manufacturers have a known set of retailers. The orders of those retailers are known while the frequency of the orders by those retailers are also known, so they send their products directly to the retailers from the warehouses, and then the retailers sell the products to the end customers. With this much simple supply chains the businesses put their entire energy in the saving of costs, i.e., the costs saving factors of choosing the right transportation methods, the right forecasting methods, the right warehouse sizes, and locations etc. Besides this, they also focus on the quality of their products to get maximum customer satisfaction.

Supply chains like the above from the manufactures to end customers are relatively easy to manage, because maximum parameters of the supply chains are known. But as the technology grows, the supply chains get more complex. In the recent days online shopping has emerged. Many manufactures offer their online shops where they sell their products directly to the customers. For the customers it is an easy way to get their orders without spending their times in search of products in different stores**,** it is an easy way to shop, a simple click and within few days their products are at their doorsteps, but in background it is really a complex job, and it becomes very challenging to fulfil the phenomenon to deliver "the right product at the right time, to the right customer at the right cost" but still the supply chain managers and firms make sure that the products are delivered to the customers in time.

With these scenarios, the supply chain complexity is increased for the business firms to serve to 'retailers' as well as to direct customers. As in the above scenario of the simple supply chains the retailers are known, their order quantity is known well in advance, but with these complex supply chains where the manufactures must serve the customers directly, it becomes a challenging task. If one customer orders a single piece of shirt, it requires almost the same pain and effort as to deliver a big lot to a retailer.

In the actual operations when a customer order only a single piece of a specific product, the product has to be located in the warehouse. It should be packed and should be sent to the customers within the shortest span of time. In this case the transport selection mode is also

complex because different customers have to be served in different parts of the world or a country.

Suppose if a business firm with its major warehouse is located in Freiburg Germany and one customer orders only one product from München, another from Duisburg, and another from Frankfurt, physically all these customers are situated in different areas of Germany, but the business firm has to make sure that every customer gets the right product at the right time, so for delivering the right product to the right customer at right time, the firm has to be very fast and accurate. Every step of the supply chain has to be completed well in time and they have to beat the competitors too. If the firm cannot deliver in time, they will certainly lose customers, and losing the customers mean losing profits, resulting in losing market share.

In short, with the emerging technologies and sharp market competition, the supply chain industry is getting more complex, and a complex supply chain with meeting all the global challenges has high tendency towards risks. Many researchers have shown a relation between the complex supply chains and risk in their research. "Risk increases with Supply network complexity and internationalization (Peck, 2004)" and risk management has become a high priority for the researchers in the research agenda (Kenneth, 2013).

Many risky decisions in supply chain like, introducing a new product, outsourcing manufacturing, expanding into new markets could result in a significant benefit to the company, but it is important to identify those risks well on time and to use the correct mitigation strategies to overcome those risks. Companies which take risks and plan for them (have mitigation strategies defined) are likely to be more successful, they should try to be proactive not reactive. However, having a mitigation strategy is also not enough; a strategic competency in responding to the unexpected is also required. This ability is a combination of agile processes and tools that allow a company to recognize an event, assess the impact, and respond accordingly (Kinaxis, 2012).

(Mckinsey, 2016) have defined the future state of supply and have predicted that the digitized future supply chains should have characteristics i.e., faster, more flexible, more accurate, more granular and more efficient. This statement already puts an extra burden on the companies and businesses to think well ahead and plan accordingly.

If companies want to excel in their business, they must know their business risks and they should choose the right strategies to mitigate the risk well on time.

1.4 Inter-Organizational Collaboration in Supply Chain

There were times when many supply chains were not dependent on others; a single company might have owned its own process of raw material sourcing, manufacturing, distribution facilities, marketing, and sales, with the entire supply chain falling under the direct control of one enterprise (O'Byrne, 2016). However, with the current growth in technology, the world has become a global home rather than a global village, and in this race of globalization, all the firms have the common goals of saving cost, grabbing more customers, and leading the Business market. In order to achieve these goals, it is need of the time that the Businesses and firms across the globe are bonded in collaborative networks. "A collaborative network is the collection of businesses, individuals and other organizational entities that possess the

capabilities and resources needed to achieve a specific outcome" (Shuman, 2008). Figure 1.2 shows inter-organizational collaboration in supply chain operations.

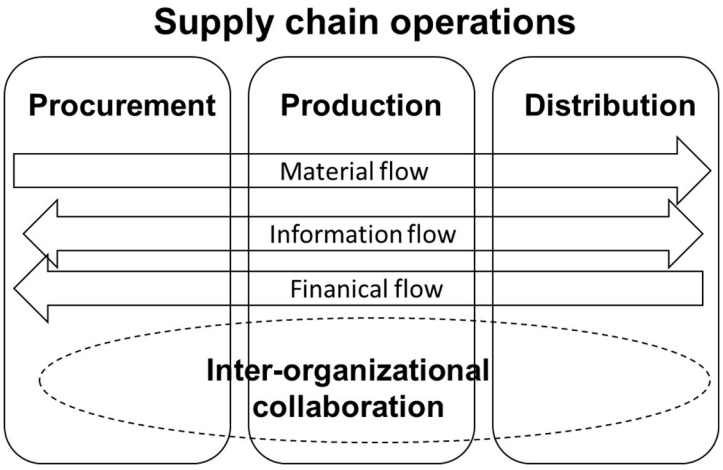


Figure 1.2. Inter-organizational collaboration: figure based on (Nurmaya, 2012) *with modifications*

Engaging in collaborations and maintaining relationships has become a major concern for the management in manufacturing and industrial companies, and collaboration has become a vital part of the supply chains across the globe. Although these collaborative networks are vital parts of the supply chains of today, still collaborations in the production industry experience a failure of 50% if not more (Dekkers, 2005). As firms collaborate and combine forces to compete as extended enterprises against other integrated supply chains, risk is linked to the interdependence among supply chain partners (Spekman, 2004). Researchers like the above and many more are finding it obvious that the collaboration is an important and integral part of the supply chains of today, and it is the way to keep a good market share. Many market leaders work in collaboration to grab a major share of the market, but another fact is that the more the collaboration increases the more risk in the supply chain increases, so all the risk must be properly identified and mitigated.

1.5 Digital Technologies of Today

In this modern world, digitization of technologies has a potential to offer efficient and unlimited solutions to the modern world problems in all ways of life. On one hand, it is about opportunities and on other hand it is about challenges. The challenges in introducing the digitization technologies needs guidance. In the span of last 10 years, countless application of digitization has been seen by the world. Development of computing technologies and connectivity provided a new horizon of progress and opportunities. Different combinations integrating these technologies can be formed and as overall it can impact and disrupt many traditional operations in many fields like IT, supply chain, and overall businesses. Recently many technologies are already applied in logistics like internet, real time GPS trackers, Smart containers, RFID, and Digital signatures enable autonomous communication during transportation. Therefore, digitization is often used as a synonym of automation. This perception is from the fact that in a task our purpose is to have documents in a digital form for a reason, so that we can initiate a chain of events and actions to use digital data, extracted from physical carriers, to automate

work processes and workflows, which is also a form of digitization. Below are the main technologies which can be referred as to digitization technologies in today's world.

I. IoT (Internet of Things)

IoT stands for internet of things. This term was firstly used by a project manager named Kevin Ashton (Gabbai, 2015). In internet of things devices can communicate with other devices. In which device is simply equipped with sensors. These sensors are having processor and is also assigned with its own unique IP (internet protocol) address to identify the device. It gives possibility to devices to communicate with each other to share information and makes intelligent decisions (CBR, 2018). The internet of things (IoT) is increasing its popularity in both industrial and domestic use. Traditionally, industrial environment is centrally managed, so the IoT technology is also used on centralized platforms in which a central hub is required to control and communicate between the devices. As in autonomous functioning devices required to communicate directly to other devices this type of connection is achieved by the development of IoT platforms which operate decentralized. This type of working of devices allows a lot of possibilities to take decision based on collected data directly (Crosby, 2016).

History of IoT: Komatsu is a Japanese manufacturing company of heavy machinery like bulldozers and excavator. This construction machinery is equipped with sensors, which collect data from machine and send it to company for monitoring the performance of machine and to plan the maintenance scheduling. This information may contain current performing conditions of vehicle which provide information to verify their normal operations as designed. This information transfers via mobile or satellite network with their GPS (Global positioning system) location as well. For this particular purpose, a system called Komtax IoT system is installed on machines. The following figure shows the communication structure, this system integrates preventive maintenance resulting in better safety management and high performance of machines with low economic operations (Hisashi, 2017).

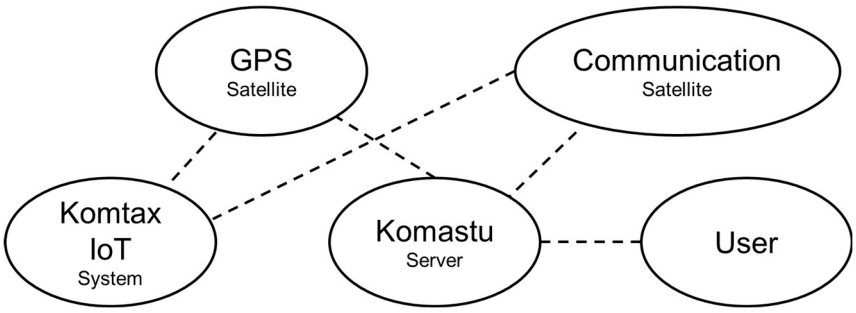


Figure 1.3. Structure of Komtax IoT communication: figure based on (Hisashi, 2017) *with modifications*

Development in IoT: Internet of things got evolved with time and is expanding its area of application from small electronic and auto parts to heavy industrial equipment. Now due to evolution and development in IoT, cost effective ready to use IoT modules are available in market. This gives the opportunity to explore its true potential (Lee, 2014). Not only device-to-device connection internet of things provides the opportunity to communicate with cloud but also IoT provides opportunity to connect logistic operations during entire supply chain. As figure 1.4 shows application of IoT in logistic operations provides series of impacts starting from monitoring the status of shipment in transport in real-time, which can perform the base of

controlling and automating the processes. This can lead to better optimization of complete business process (Macaulay, 2015).

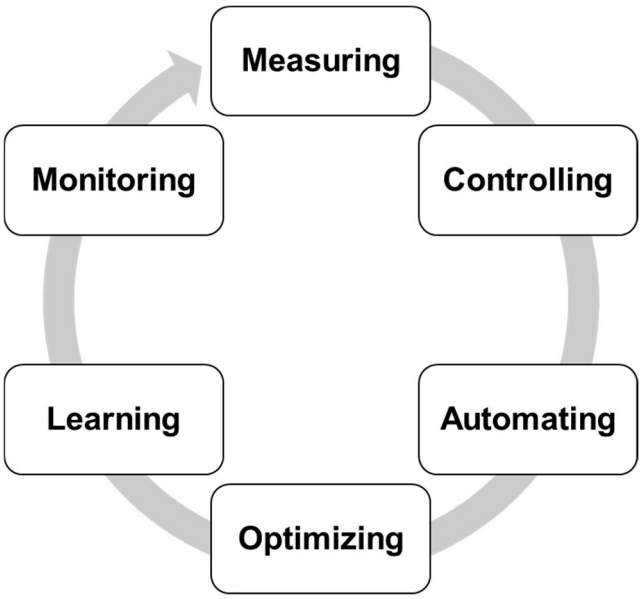


Figure 1.4. IoT- enabled capabilities: figure based on (Macaulay, 2015) *with modifications*

II. Artificial Intelligence (AI)

Artificial Intelligence, also commonly known as (AI) refers to the simulation of human intelligence in machines, which are programmed to think and act like human, Artificial Intelligence is based on the principal that human intelligence can be defined in a way that a machine could easily perform the tasks assigned to it (Frankenfield, 2021).

The term Artificial Intelligence was used by John McCarthy when he organized “the mythic Dartmouth conference” in 1956. He defined AI as the science and engineering of making intelligent machines (Openmind, 2016). AI can also be referred to as cognitive technologies, where certain algorithms and data sets are employed to learn system artificially. Mainly AI is divided into three types of systems, which includes analytical, human inspired and human based artificial intelligence.

AI is aimed to deal with problems targeting reasoning, planning, learning, perception, and manipulation. Its approaches include data sets, big data sets, statistic models based on reasoning and probability. In simple words, AI is a robust technology that uses its environment to learn and take decisions in order to achieve maximum results or best possible results.

Recently, the development of technologies like Big Data and Data Science has provided the base for such technologies to grow and to get implemented in commercial use. Artificial intelligence provides logic-based decisions; these logics may be in the direction of cognitive simulation, knowledge-based, embedded intelligence, computational intelligence, and soft computing.

AI makes it possible for machines to learn from experiences, adjusts to new inputs and performs tasks the way human does. AI heavily relies on the concepts of natural language processing (NLP) and deep learning. Using these technologies, computers/machines can be trained to perform specific tasks by processing large amount of data and recognizing patterns

in the data (SAS, 2019). Manufacturing robots, Self-driving cars, Smart assistants, Social-media monitoring, Proactive healthcare management etc., are the examples of available AI products (Daley, 2021).

III. Industry 4.0

Industry 4.0 also referred as the fourth industrial revolution is marked by the main and core technologies used in the manufacturing process.

In the late 17th century, the concept of mechanization came into idea where other forms of energy could be transformed to mechanical energy, that can lead to industrialization. This era was known as the 1st industrial revolution. In this era technologies like steam engine and looms came into existence. In the late 18th century, the concept of mass production took place where factories were setup with conveyer belts to produce item or entities for instance, automobile manufacturing. This time-period and production period in mechanization is marked as the 2nd industrial revolution. In the late 19th century, with the introduction of internet revolution and computing technologies, the industrial production took a massive leap and changed its core manufacturing processes. It gave rise to automation technologies where sensors were used for manufacturing. This era is regarded as the 3rd industrial revolution.

Industry 4.0 is termed, as high-tech manufacturing strategy where production facilities include cyber physical system, cloud computation and internets of things. It is termed as industry 4.0 or “the fourth industrial revolution”. It has given the concept of smart factories where human-less factories interact within the system to produce the goods. Usually, it is in the direction of robotics. Figure 1.5 represents the development of industrial era from first industrial revolution to current industrial revolutions.

With the development of technologies with new industrial revolution, the degree of complexity is also increasing exponentially. Figure 1.5 also shows that the gap of degree of complexity is increasing wider with the change of every industrial revolution. In order to have the pace of industry, every type of industry must strive for constant development effort which can give it edge over competitors.

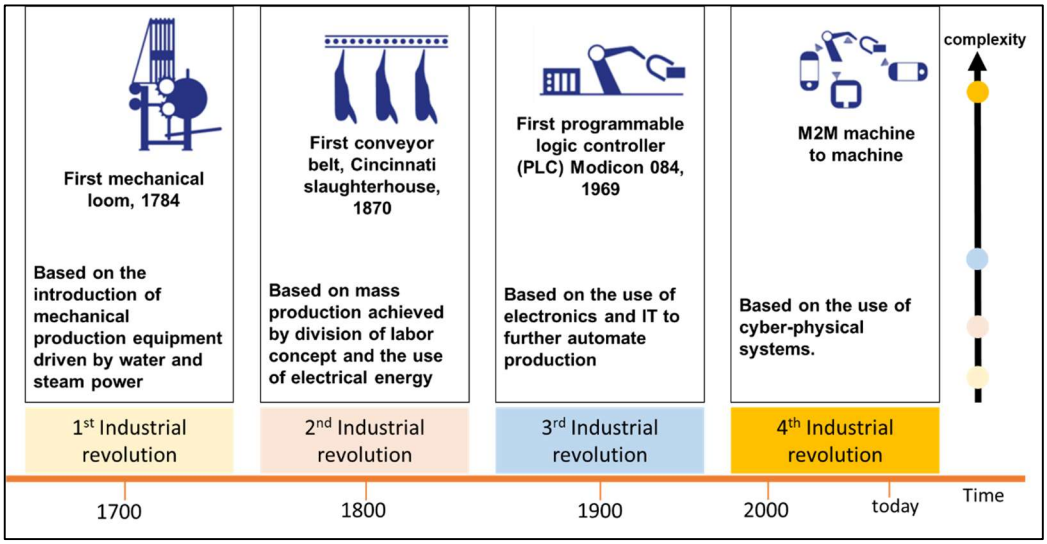


Figure 1.5. From industry 1.0 to industry 4.0: figure based on (Siemens, 2021) *with modifications*

Industry 4.0 has its own design principles for implementing a manufacturing scenario. These principles include the communication between devices via IOT or IOP. In principle it includes vast amount of useful data and information transfer, which is decentralized and transparent. Industry 4.0 is an abstract word, which includes many integrated technologies. Technologies like smart devices, human machine interface, machine-to-machine interface, cloud computing and smart sensors are such technologies that are contributing in the direction of Industry 4.0. There are also some challenges in the large-scale implementation of industry 4.0. These challenges are budget, cost, robustness, and skilled manpower. Efforts are being put in this regard. Many decisions are also government dependent but with every passing day more and more research is being carried out in this field.

IV. Blockchain

Blockchain is a tamperproof and irreversible database, distributed along a network which records information in a continuously growing basic unit called block (Swan, 2015). Blockchain is based on the idea of distributing data in a network rather than saving it on a central storage point. Blockchain can be described as distributed digital ledger, which records digital information and shares it to a distributed network (Nakamoto, 2008). Nakamoto presented idea of Bitcoin based on Blockchain which is a distributed ledger technology.

Blockchain is new type of database, which is owned, operated, and watched by each participant of the database. Each participant has access to it and power to update and takes part in approving updates of other users. In comparison to traditional databases, Blockchain does not use centralized authority to control the database, instead it gives power to all participants. The participants form a network which is decentralized in nature. Each time when an update is needed in the database, it is approved by consensus of users. Once the consensus is made, the transaction is approved, and a new block is formed which is attached or chained to previous block forming a series of chained blocks; that is why it is called a Blockchain. This data is cryptographically secured and results in an authentic and verifiable database (Fisher, 2019).

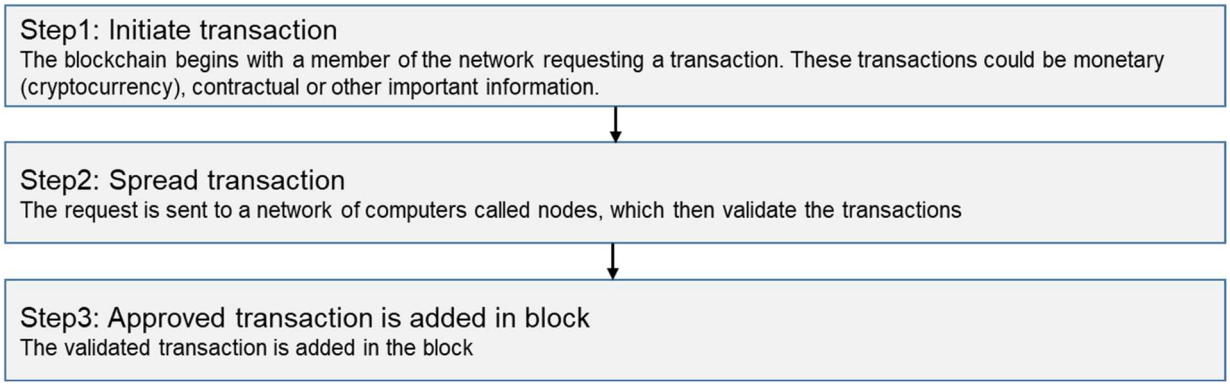


Figure 1.6. Basic steps to add transaction in block: figure based on (Fisher, 2019) *with modifications*

V. Cloud Computing

Cloud computing is one of most discussed technologies in today's world of digital transformation and it is considered to be the future data management. Cloud computing is the delivery of computing services i.e., storage, databases, networking, software, storage, and analytics etc. over the internet (Azure, 2021). It is the on-demand delivery of IT resources over the internet, instead of buying, maintaining, or owning the data centres and servers; the users can access the technology services with a fee (Amazon, 2021). Software as a service (SaaS), Infrastructure as a service (IaaS), Platform as a service (PaaS) are the typical types of cloud computing. Many big companies like Google, Amazon, Microsoft, IBM etc. are already offering cloud services to their customers.

1.6 Research Objective

Supply chains are exposed to risks with the current development in technologies and with the supply chains bonded in collaboration; these collaborations are making the procurement processes more complex and challenging. Many people still believe that procurement is simply the process of buying products or goods for any organization, which is not correct. Procurement has responsibilities a lot more than that.

The objective of this research is to analyse how the supply chain risks can be managed effectively, what are risks associated with the procurement processes and how automation of all the procurement processes will improve the overall performance of procurement. The procurement processes are discussed in detail and for each procurement process an automation concept is given and is tested with experiments to achieve the goals. Different research papers, interviews, practical experiences have been used to identify and fill the gaps in the current conventional procurement processes through automation. To accomplish this objective, table 1 shows 5 blocks of research questions that should be answered.

RESEARCH QUESTIONS	EXPLANATION
Why is Supply Chain Risk Management considered, to be the most important branch of supply chain and what are risks associated with supply chain?	▪ What are the key issues, which can affect the supply chain process? ▪ How the performance of supply chain could be analysed from risk management point of view?
How can Blockchain Technology have an impact to mitigate supply chain risks?	▪ What is the Blockchain technology from different perspectives? ▪ What are the basic terminologies of the Blockchain technology? ▪ How a Blockchain based supply chain is more risk resilient?
How is Procurement more than just purchasing and what are the risks associated with different Procurement types?	▪ What are the types of Procurement? ▪ What is the difference between Operational, Tactical and Strategic Procurement and how are they dealt with in different organizations? ▪ What are the risks associated with Operational, Tactical and Strategic Procurement? ▪
Why automation of Procurement processes is the need of time and what are the possible benefits?	▪ What are the possible benefits of automation of Operational, Tactical and Strategic Procurement and how all these processes can be linked to achieve the success targets?
How automation of Procurement processes justifies the proposed benefits and KPI's and why my proposed concept is better than the traditional methods?	▪ Which different models and techniques are used, to eliminate risks associated to different Procurement types? ▪ How my experiments justify risk mitigations in all Procurement types?

Table 1. Research questions and explanation (own content)

Chapter 2: Supply Chain Risk Management

Supply chain risk management is currently more critical than ever in all sectors of the industry. The potential impact of the supply chain risks on the core business and reputation of an organization cannot be underestimated but the supply chain leaders are getting smarter (Knut, 2020).

In this chapter, the supply chain risk management has been discussed and different types of risks which can interrupt the supply chain processes are introduced with the relevant definitions and important literature. With the development of new technologies, in every field of businesses, there is regular need to update supply chain to match the pace of industries and provide solutions to new problems or make competitive edge. Businesses are going global in order to gain economic benefits by producing goods in developing countries which makes the supply chain more complex. Due to fluctuation in business requirements, the supply chains are in great pressure.

Supply chain is required to be proactive to detect and act quickly against any disruption. Supply chain is a system which contains elements like suppliers, manufacturers, distributers, retailers, and customers; these elements are connected for material, finance, and information flow in both directions (Fiala, 2005). Supply chain is a series of operations and activities which are needed to move items from raw material to finished products to end user (Donald, 2007).

2.1 Supply Chain

Supply chain is a system which contains elements like suppliers, manufacturers, distributers, retailers and customers and these elements are connected for material, finance, and information flow in both directions (Fiala, 2005). In other view, supply chain is a series of operations and activities which are needed to move material from raw material to end user (Donald, 2007).

Supply chain is more than just transportation of goods. It includes planning, arranging resources, transforming resources into finished products, and transporting them to the end customers. Supply chain council in USA has developed a model to represent supply chain as shown in figure 2.1. This model is mainly proposed for manufacturing supply chains, but it is possible to use it in retail and services supply chain with some modifications. Main operations of the model are Plan, Source, Make, Deliver, Return (PSMDR).

First Step is the planning of the product, deciding the product according to customer requirements and selecting the location of the production. Second step is the sourcing process of arranging the required raw material to manufacture the required product. Next step is to manufacture the products. During the manufacturing process, there are many types of transportations involved within the manufacturing facilities.

After manufacturing, the products are delivered to the end customers. All these processes are under the umbrella of supply chain. A complete supply chain process generates a lot of data and complexity.

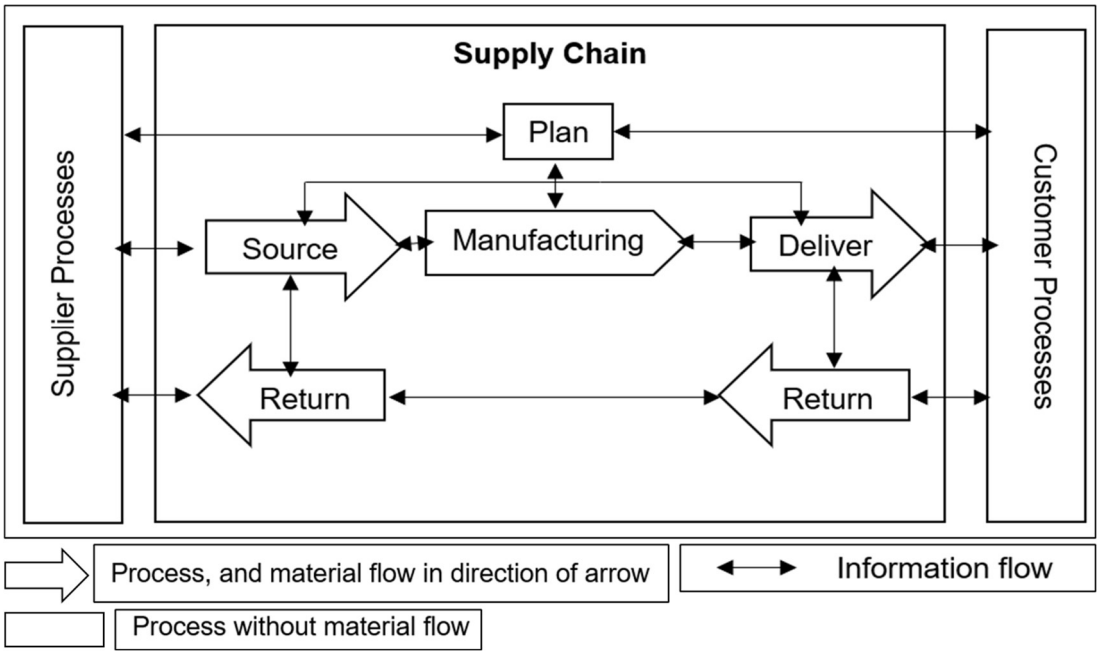


Figure 2.1. *Supply chain components: figure based on (Mossallam, 2018) with modifications*

Outsourcing is one of the most common trends in supply chains, in which products or services are purchased from other companies (local as well as international) that expose the supply chain to many risks. Procurement is an important field of supply chain to manage these outsourcing projects, which is discussed in chapter 3 in detail.

2.2 Supply Chain Management

Supply chain management is the management of flow of goods and services, and it includes all the processes, which transforms raw materials into final finished products (Hayes, 2019). The primary objective of supply chain management is to improve the service level to the customers and to reduce the overall supply chain costs (Teeboom, 2018). Figure 2.2 shows supply chain management and business areas associated to it.

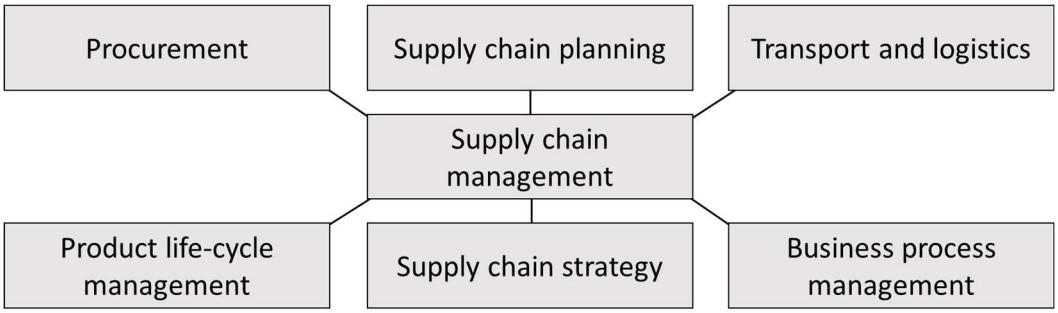


Figure 2.2. Supply chain management: figure based on (Microtech, 2017) with modifications

2.3 General Framework of Supply Chain Risk Management (SCRM)

In earlier days the focus of the supply chain management used to be on the material flow, financial flow, and information flow, but in fact the risk events which have a direct or indirect influence on the supply chain should also be considered as one of the important focal points and should be taken seriously.

After the major incidents presented in chapter 1, which took place at different parts of the world, showed vital disturbances in all sectors of supply chains; while in fact the disturbance started at only one sector in the beginning and then spread like a virus resulting in major disruptions throughout the entire supply chains.

Supply chain risks can be mitigated when the risks and their root causes are identified. In recent times, the risk management is considered as a new norm and is a hot topic in the supply chain industry. Different researchers have shown interest in the supply chain risk management sector and similar ideas have been presented by (Nurmaya, 2012), (Chopra, 2004), (Johnson, 2001), (Spekman, 2004) all these authors have tried to identify the dimensions of risk in the supply chain operations.

(Spekman, 2004) in their research have concentrated on the emerging technologies of information sharing and network relationships, further adding the security of internal information systems among supply chain partners and corporate social responsibility to their risk dimensions. (Nurmaya, 2012) in his research has tried to develop a conceptual model for analysing the supply chain risk management; he also has presented a good view of the supply chain risks and mitigation techniques. His area of focus is on the material flow and financial risks of the supply chain.

The focus of this chapter is to identify all the possible risks which can have an impact on the supply chain operations and further going in the details of “procurement risks". As procurement has different types, so different solutions to mitigate the risks associated with different procurement types are proposed and have been discussed with their pros and cons in details.

Figure 2.3 shows the framework of supply chain risk management. The supply chain can be affected by different risks. A series of risks which can affect the supply chain is also presented in this chapter. When risks interrupt any supply chain, the performance of the supply chain is affected, different risk types can have different impact on the supply chain performance, therefore a solid risk analysis process could identify the impact of disruption on supply chains. At the end the risk consolidation and mitigation policies should be applied in order to achieve maximum supply chain performance, for instance the impact of disruption on flows could be improved or diminished or avoided. It is also presented that how the procurement processes react to supply chain collaborations and how the risks are increased with the collaboration, all these risks have been identified and it is also shown how a risk interrupts different parts of the supply chain.

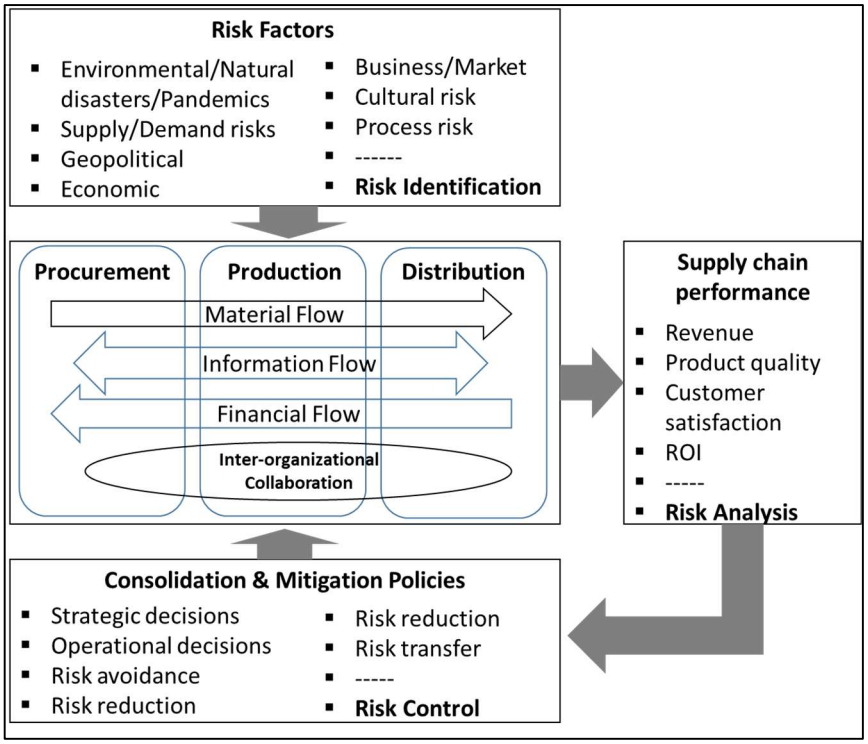


Figure 2.3. General framework of SCRM: figure based on (Nurmaya, 2012) *with modifications*

2.4 Understanding Risk – Risk Literature

In earlier time, risk used to be simply linked to the unexpected events but with the passage of time and continuous interest of researchers in the risk management areas, different researchers define risks in different ways.

This section shows, how different researchers have presented relevant definitions of risks in their research work. (Christopher, 2004) define risk in their research as the “effect of external events such as wars, strikes or terrorist attacks and impact of changes in business strategy”.

Risk can be defined in different ways, it is the probability of an unforeseen occurrence of an event, which can have a negative impact on any business. In general, the supply chain risk is considered to have negative impact on supply chain; it is important to manage risk in order to gain maximum productivity. Risk is a direct measure of probability of its occurrence and its potential degree of damage that can take place by selecting the given risky situation (Lowrance, 1980). Risks are the possible chances of taking place of an uncertain outcome or situation that have negative effects on the results of a project (Simon, 1997). Another general definition can be, risk is outcome of likeliness of an event to occur at a certain time and location, which has the possibility to adversely impact on the organization (Kerzner, 2006).

Overall, supply chain of today is more complex and challenging as it was never before. With businesses going globally, there are different modes of procurement and transportation involved especially for international supply chains. Companies manufacture their products in economical parts of the world and then sell the products in other parts of the world to gain maximum commercial advantages. This leads to relatively long supply chains, which are quite challenging and require a lot of time and resources. A slight change in demand or a disturbance

in scheduling can lead to a high cost. At the same time, this can also lead to different types of risks like penalties, loss of perishable items, delays for goods in lean manufacturing, where goods are planned for just-in-time etc. Another risk, which is common nowadays, is the unclear traceability of goods in transportation during its entire lifecycle. The traceability of products can give confidence to users about its originality, genuineness, and origin.

Anything in supply chain that disturbs the flow of information or material from base supplier to end customer is considered as risk in supply chain (Norrman, 2002). Authors (Kleindorfer, 2005) relate risk to natural disaster, strikes, earthquakes, economic disruptions, terrorism, and political instability. Authors (Chopra, 2004) categorize the risk into 9 categories in their research, which include disruptions, delays, systems, forecast, intellectual property, procurement, receivables, inventory, and capacity.

According to (Deloach, 2000), risk is the "level of exposure to uncertainties that the enterprise must understand and effectively manage as it executes its strategies to achieve its business objectives and create value". A more standard definition of risk is " risk is a chance, in quantitative terms, of a defined hazard occurring" (Brindley, 2004)

"Risk is a painful reality in every business today. Strategic initiatives like low-cost-country sourcing and supplier rationalization programs only increase manufacturer's exposure and vulnerability to the risk of supply chain disruptions, the recent studies have shown that even the most sophisticated companies need a reminder for the different types of risk, and how to mitigate each" (Lawton, 2007).

While reviewing the risk management literature, it becomes difficult to distinguish between supply chain risk and the uncertainty in supply chain operations, therefore the risk is often confused with uncertainty. An uncertainty is a situation, where an outcome is unknown when the input is unknown. In uncertainty, probabilities are possible to calculate. Whereas risks have an outcome from a known possible set of outcomes which make it possible to quantify and manage (Surbhi, 2017). A comparison between risk and uncertainty is shown in table 2.1.

Comparing base	Risk	Uncertainty
Defining	The probability of gaining or losing a certain thing is known as risk	Uncertainty is in a situation where future of a certain event is not known
Outcome	Chances of outcomes are known.	The outcome is unknown
Controllability	Possible to control	Impossible to control
Probability quantifiable	Assignable	Not assigned
Minimization	Yes	No

Table 2.1. Differences in risk and uncertainty: figure based on (Surbhi, 2017) with modifications

Risk in literature is not always referred to an event with the possibility of effecting negatively, some risks are also positive in nature which are taken in terms of opportunity. To take a decision in risky environment is the process of choosing from different scenarios as all scenarios have different outcome and probability of outcome is also variable (Kahneman, 1979). Figure 2.5 shows a risk matrix which illustrates that how the supply chain risk has an impact on the overall business. The probability of the supply chain risk is directly proportional

to the impact on the business, it means that higher the probability of the supply chain risk, higher the impact on the business.

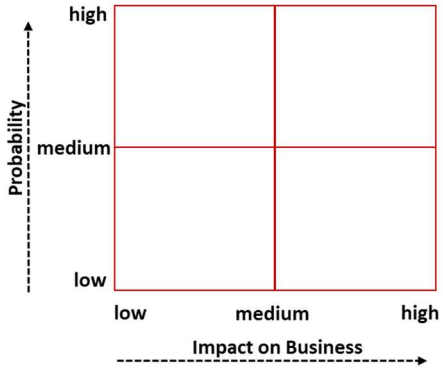


Figure 2.4. Supply chain risk matrix: figure based on (Brindley, 2004) *with modifications*

Companies can reduce or limit the impact of the supply chain disruptions by identifying the risks within their supply chains and developing the right ways and strategies to mitigate them. It is important to identify the disruptions within the supply chains in order to excel in the business market. This process should be documented in the risk management plan, which is part of the overall business plan (Queenland, 2013).

2.5 Supply Chain Risk Management Process

Supply chain risk management is the process which shows how the risks associated to the supply chain can be properly managed. (Carter, 2008) define supply chain risk management as “the ability of a firm to understand and manage its economic, environmental, and social risks in the supply chain”. It could be materialized by the adoption of contingency planning and having a resilient and agile supply chains (Nurmaya, 2012). As shown in the figure 2.5. the supply chain risk management process consists of two elements 1. Supply chain risk analysis, 2. Supply chain risk control.

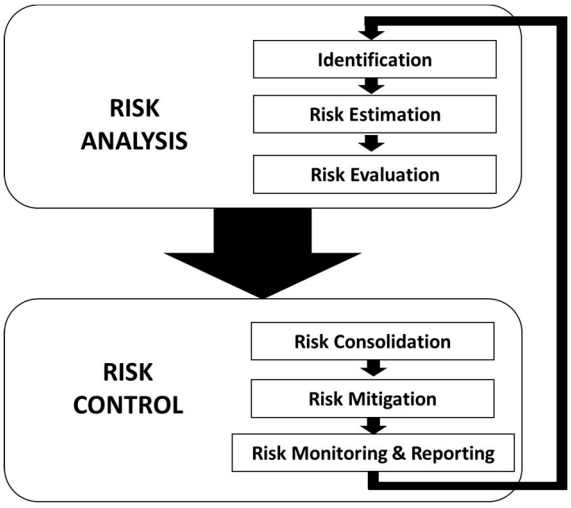


Figure: 2.5. Supply chain risk management process: figure based on (Nurmaya, 2012) *with modifications*

In order to fulfil customer requirements in industrial organizations, many decisions are taken to deliver products and services, these decisions also include risks. Quality Management and ISO 9001 quality standard recommends that in the management of activities, organizations should define processes to provide the basis to decide required action (Wilkinson, 2002). Organizational processes can be classified in different types, based on the type of organization. Most general classifications are operational, support and management process. Revision of new management standard ISO 9001:2015, gives special consideration of risk management to take risk aspect in account in an organization. ISO 9001:2015 defines steps to identify risks in processes at very basic level and mitigates it by risk management activities (Hammar, 2019).

Risk management identifies and develops strategies to coup with unknown events, which may occur and may influence organizational performance level or output. Risk management process is a systematic approach to identify, quantify, manage, and communicate risk. Once the risk assessment is done, a specific approach is selected to treat the risk in order to minimize or eliminate risks or plans are made to reduce the negative effects of the risks. If the risks are unavoidable, risk management plan is developed to resume the operations of organization as early as possible in order to restrict the damage under an acceptable limit.

Figure 2.6 shows the risk management process given in an international standard ISO 31000 model. All the processes of this model are explained below.

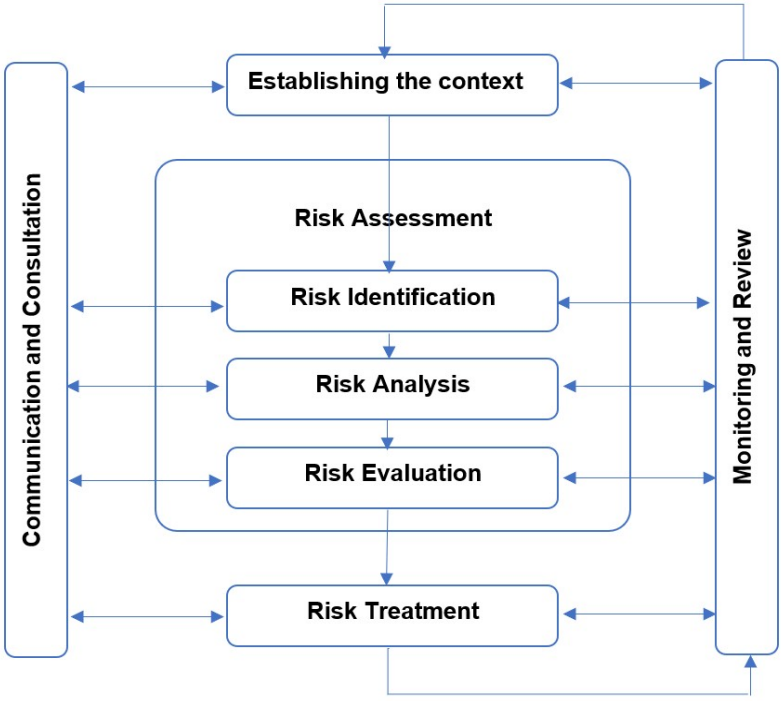


Figure 2.6. Risk management process based on ISO 31000: figure based on (Steen, 2015) *with modifications*

I. Communication and Consultation

In risk management process, there is a need to communicate and consult regularly with all involved internal and external stakeholders to develop a plan. The plan should contain

introduction of risk, its effect and how it can be managed. During this step opinions are collected from all the stakeholders and are considered in decision phase.

II. Establishing the Context

It is highly important to establish the context of the risk; it means to include all the parameters about the risk, further in this process, all internal and external parameters are taken in scope of risk and relevant process selection.

III. Risk Assessment

Risk assessment is one of the most important steps in the risk management process; it is the identification of hazards that could have a negative impact on ability of an organization to achieve its targets (Cole, 2020). Risk assessment is combination of the following three steps.

a. Risk Identification

In this step, the potential risks and their types are identified, proper risk identification methods enable businesses to develop effective plans to minimize the impact of the risks (management, 2020). There are different types of risks. Generally classified under external and internal risks, these are further explained in detail in next section.

b. Risk Analysis

In this phase the causes of risk, sources and its effect on the outcome is analysed. Probabilities are calculated and the degree of risk for each type of risk is determined. During risk analysis common effect of different risks is also identified.

c. Risk Evaluation

After risk analysis, risk is quantified in the evaluation process and sequences of treatment of risk are also decided. The risk evaluation is an important step as it identifies the severity of the risk, and it is the base of how the risk should be treated.

IV. Risk Treatment

The next step is to treat high level of risks, for this purpose, innovative methods are established, or pre-established techniques are used. Treatment of risk, before it occurs is always preferred rather than dealing with its consequences when it is occurred. Risks are prioritized based on their nature and the response strategies are developed. Performance of risk treatment is continuously monitored, communicated, and the cycle is continued till the risk is reduced or mitigated.

V. Monitoring and Review

Monitoring the risk closely is an important phase of the risk management process. Every step in the process is continuously monitored and reviewed and the level of risks is tracked and evaluated. This part makes sure that every previously captured information is properly stored and integrated in decision making (Aleksić, 2009). The findings from this process-step help the organization to find improvements strategies which could be used to mitigate the risks

2.6 Supply Chain Risks Types

The risks associated with supply chain can be divided into two main types

- External risks
- Internal risks

These risks have a great impact on the supply chain, which results in losses for the overall business. Some of the risks associated with internal and external risks are shown in figure 2.7.

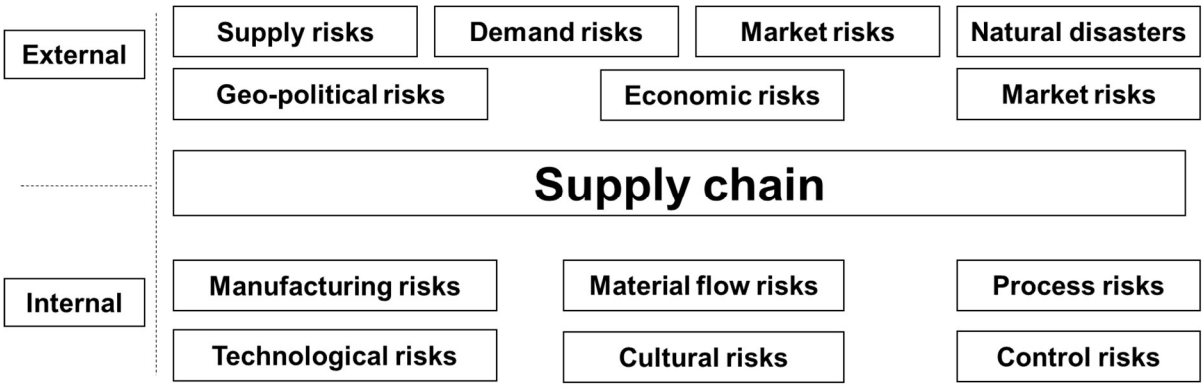


Figure 2.7. Supply chain risks: figure based on (Cranfield, 2003) *with modifications*

2.6.1 External Supply Chain Risks

Those risks which have an impact on the supply chains from outside and are out of one's control or one can have very little control on them are called external supply chain risks; but when they are properly identified, they can be controlled and can be mitigated. Below are the types of external risks.

1) Supply Risk

Supply risk is one of the most common risks associated with any supply chain and it is one of the most important risk which must be dealt with. The supply risk should be properly and timely identified and mitigated at the earliest, because this risk mainly occurs on the supplier's side or in the procurement phase of the supply chain. The supply risk results due to an interruption in the flow of products, the flow could be of raw material or parts etc., within a supply chain (Queenland, 2013).

If the supply to a production process is disrupted, the production capacity would be disrupted, and all the following processes of the supply chain would be affected.

Taking the example of the Ericson crisis, it was a natural disaster which affected the supply line of chips for the Ericson production operation resulting in a disaster for Ericson in terms of production. The main element which brought Ericson to bankruptcy was the 'supply risk', not the natural disaster. If Ericson would have used two or more suppliers for their chips, their production would have not been affected so badly and perhaps they would have survived from the crisis as Nokia did.

According to (Lall, 2011) a supply risk can also be defined as "the possibility of disruptions of product availability from the supplier or disruptions in the process of transportation from the supplier to the customer". A supplier may not be able to complete an order due to several

reasons, including problems in sourcing necessary raw materials, equipment failure, damaged facilities, or any other unlikely disruption. The products in transit can face transportation disruptions leading to high delivery lead time. The transportation disruptions may be caused by delays in clearance, traffic conjunctions or problems with the mode of transportation.

(Metricstream, 2011) in their research identified risks which can take place at a supplier side, they are presented below.

- Procurement Risks
- Early/late shipments or delivery to wrong location
- Non-conforming/wrong product or quantity
- Supplier processes
- Sole source supplier
- Deteriorating performance
- Credit/financial problems
- Labour practices
- Long-term investment in capacity, innovation, performance, etc.
- Capacity ramp/rollout problems

2) Demand Risk

Supply chains are most frequently prone to demand risk. An automation concept to deal with the demand risk is presented in chapter 10.

Different researchers define the demand risks in different ways, according to (Makers, 2001) (Cranfield, 2013) "Demand risk relates to potential or actual disturbances to flow of product, information, cash, emanating from within the network, between the focal company and the market. This demand risk can be a failure on either the high or low side to accurately accommodate the level of demand". The demand risk can be caused by unpredictable or misunderstood customer demand (Queenland, 2013).

(Lall, 2011) in his report compares the demand risk with the supply risk, according to him the demand risk is the downstream equivalent of supply risk and the demand of the supply chain is prone to this risk.

The demand risk may arise due to an unexpected increase or decrease in customer demand that results into a mismatch between the forecast and actual demand of the company. Further (Lall, 2011) and many other authors write in their reports that, an increase in customer demand leads to depletion of safety stocks, resulting in stock-outs and back orders while on the other hand a fall in the customer demand leads to increased holding costs and price reductions. (Lawton, 2007) describes a demand risk as demand and inventory fluctuations and challenges. While some suppliers jump at the chance to take on new opportunities, but enthusiasm does not necessarily mean they are in the best position to excel.

In the real world the demand risk is taken quite seriously by every organization, they are quite aware of the demand risk within their supply chain. The demand risk is one of the most common risks to the supply chain industry. If it is not taken seriously, it can have a very costly impact on the business and on the entire supply chain because all the processes of the supply chain are very strongly inter-connected.

3) Market Risk

The market risk is also an external risk to the supply chain, and it has also a great importance to be kept under control because it is the market where the companies can excel in their business. Market risk encompasses the risk of financial loss resulting from movements in market prices (Market, 2013).

The main aim of the supply chain of any company is to grab maximum customers, which means a greater market share of the business. However, it is not that simple to get maximum market share because there are many competitors in the market, which may provide the same product, therefore, the management of the companies should make effective strategies to keep maximum customers under the umbrella of their company and get a maximum market share.

It is not only about grabbing maximum market share, but it is also important to understand the norms of the market. The companies should identify the market situation before entering the market for business; it is one of the most important decision to be made by the company's management. Taking countries as an example where there are unrests, the company's planners should well plan before entering that market for business.

4) Environmental Risks / Natural Disasters

The most unforeseen risk to the supply chain is the environmental risk; this risk has shaken up the world and has compelled many researchers and business firms to take the supply chain risk management as a serious job. Environmental risks i.e., natural disasters as well as many other unforeseen events made firms more aware of the vulnerability of their supply chains and encouraged them to seek ways to reduce risks of such unforeseeable situations and increase stability along their supply chain (Gillai, 2006).

All supply chains are prone to environmental risks, but it is important for the logistics management and business planners to ensure safety measures to cope up with the environmental risks. The real-world example presented in chapter 1 shows that the most devastating losses resulted because of the natural disasters. Environmental risks can be natural disasters (earthquakes, floods etc.), terrorist attacks etc.

Studies have shown that natural disasters have caused maximum damage to the supply chain more than any other risk, the Ericssion crisis is the perfect example.

Supply chain disruptions caused by external events can have a significant financial and operational impact on firms. They are not properly prepared to tackle these disruptions; therefore, improving disaster preparedness in supply chains is more critical. The Natural disasters usually hit a big area and result in widespread damage to several firms and facilities at the same time. They have severe impact on any industry and a significant time is often required for recovery from natural disasters (Ye, 2012).

A critical component of disaster management planning in supply chains is the storage of emergency supplies, equipment, and vital documents that would be needed in time of crisis (Hale, 2005). Authors (Ye, 2012) in their report have presented a survey (Figure 2.8) of the impact of the Thai 2011 floods on Japanese enterprises, which shows how severe the impact of natural disasters on the firms is.

Sector	Industry type	Number of companies with direct damage, such as damage of buildings and equipment	Number of companies with direct damage inside the inundated industrial estates	Number of companies with direct damage outside inundated industrial estates	Number of companies with indriect losses due to supply chain disruptions	Not affected	Number of companies participated
Manufacturing	Food processing	4	2	2	11	3	14
	Textiles	3	1	2	5	2	9
	Chemicals	1	1	0	19	4	24
	Stell and other metal	2	1	1	24	3	29
	General machinery	5	5	0	8	4	12
	Electronics	20	18	3	31	2	36
	Automotives	7	6	1	47	8	56
	Others	9	7	2	26	7	38
	Manufacturing Total	51	41	11	171	33	218
Non-manufacturing	Trading companies	5	4	1	45	9	45
	Retail	3	3	2	8	3	11
	Finance	2	0	2	10	5	16
	Construction and civil engineering	5	3	3	8	9	17
	Transport and communication	2	0	2	18	5	23
	Others	1	0	1	15	12	24
	Non-manufacturing Total	18	10	11	104	43	136
Grand Total		**69**	**51**	**22**	**275**	**76**	**354**

Figure. 2.8. The impact of the Thai 2011 floods on Japanese enterprises: figure based on (Ye, 2012) *with modifications*

Further to the natural disasters, other environmental impacts i.e., terrorist attacks (the terrorist attacks can be referred to manmade disasters) has also great impact on the supply chains. Following terrorist attacks in recent years, companies are taking multiple steps either voluntarily or to meet mandatory government regulations to ensure safe transit of their goods across international borders (Gillai, 2006)

Another practical example of terrorist attack disrupting the supply chains is that, more than 100,000 ISAF/NATO troops were serving in Afghanistan in the war against terrorism. Many companies served these troops for food supplies. The supply route was via Pakistan, since 2008, many terrorists' attacks took place on NATO supply vehicles, disrupting the supply chain for these companies. When these attacks became more frequent, the companies were compelled to find alternative routes to Afghanistan, and they succeeded by finding alternative routes to Afghanistan through Russia etc.

The risk of the negative environmental impacts has become more prevalent in today's global supply chain activities. Supply chain managers and planners need to consider the risks of climate change, natural disaster etc. in developing supply chain strategies for their organizations and it is important to focus on the research on the impact of natural disasters on sustainable supply chain management in context of the increasingly globalized nature of sourcing, cooperation, competition and inter-connected business networks (Young, 2012).

5) Geopolitical Risks

Politics plays a vital role in today's global collaborative supply chains resulting in geopolitical risks; this risk is also a vital risk to the supply chain industry that can have a great impact on the supply chain operations. Every business which is involved in the flow of goods and in dealing with the emerging markets is exposed to geopolitical risks. Although there are many supplies of raw materials and other goods in the emerging markets, but the geopolitical risks are also significant and can have an impact on the bottom-line profit of most businesses (Monaghan, 2011). Author (Appel, 2012) in his report shows that the geopolitical disruptions consist of a range of potential disruptions, which includes conflicts, unrests, terrorism, corruption, and organized crime. The effects of terrorism on global supply chains are illustrated by a cumulative increase in expenditure of over US$ 1 trillion in the US domestic homeland security since 9/11, as well as a range of new industry regulations and requirements across supply chain and transport networks.

6) Economic Risks

The Economic risks are also considered to be very important. The economic risks cover a wide range of disruptions which include currency fluctuations, sudden demand fluctuation, commodity price volatility, border delays and ownership/investment restrictions. Many of these have been highlighted by the global financial crisis in 2008 and the Eurozone crisis (Appel, 2012). Author (Pierce, 2020) writes in one of his reports that " The profit point, supply chain survey report 2012 found that, globally only 70 percent of supply chain experts are able to estimate their supply chain costs accurately". This risk is also deeply connected with the demand risk and explained in detail in chapter 10.

2.6.2 Internal Supply Chain Risks

Internal supply chain risks are referred to the risks which are inside the supply chain. There are many risks which are related to the internal supply chain risks but some important are presented here. The Internal risks give better opportunities to be mitigated because they are inside business's control.

1) Manufacturing Risks

Manufacturing is the important core of the supply chain, having a great importance. The manufacturing process varies from supply chain to supply chain and at the same time the risk associated with manufacturing processes also changes from normal to the worst, taking the example of automobile manufacturing, chemical manufacturing, textile manufacturing, etc. According to an early study research of (Svenson, 1984) for the Volvo motors, there is a huge risk of human injury and death in the automobile manufacturing.

The concept of “sustainable manufacturing” is becoming an important topic in terms of environment (Nakano, 2010). Manufacturing risk is caused by disruptions of internal operations or processes, this is the risk associated with events that are related to internal operations of the firm. Examples include fire or chemical spillage leading to plant closure, labour strikes, quality problems and shortage of employees (Nakano, 2010). In current days almost all the firms consider the manufacturing risks very seriously and take all possible steps to identify these risks and use different strategies to mitigate them well in time.

2) Technological Risk

As the Supply Chains are bonding in collaborative networks, the use of new technologies is obvious to ensure maximum throughput in less time and costs which are of course advantageous but adopting more technologies brings a lot of risks to the supply chain. The technology which has been used in the supply chain is the “Information Technology”. Many businesses implement IT solutions and rely on the information technology to improve their supply chain processes but still some past facts show that the investment in IT does not or cannot guarantee enhanced organizational performance (Wu, 2006). RFID (Radio Frequency Identification) is considered as a potential technology for optimizing the supply chain processes because it helps to improve retail operations from forcasting demand to planning, manufactering, managing inventory and distribution (Ustundag, 2009).

But it is also a reality that the more the companies rely on information systems, there is a greater chance of a failure because if everything is networked, a single disturbance can affect the whole system. e.g., The "love bug" computer virus in 2000 infected and shut down email systems at NASA, Pentagon and Ford among many others, this caused estimated damages in billions of dollars (Chopra, 2004). This means that the risks related with the technology can have devastating results on supply chains.

3) Material Flow Risk

Material flow risks refer to the risks involved in the physical movement of objects within and between supply chain elements. These risks can be in the transportation of goods, delivery movement, storage, and inventories. In a situation of a risk, the material flow will be disturbed due to transportation incapability, halted manufacturing, lack of capacity, inability to access inventories (Nurmaya, 2012).

4) Planning and Control Risks

Good planning is the key to success of any process, but planning is one of the most challenging tasks in any process and thus are prone to risks; these risks are also part of the internal risks. These risks can occur due to improper assessment and planning which sum up to ineffective management.

5) Performance Risk

This refers to the performance of any business firm, related to the quality of products of that business firm. In order to survive in the world of a global competition, the firms must maintain a best performance. If the performance is up to the mark, the business firm will be able to achieve the maximum market share but there is always a risk of giving poor performance in the ongoing supplier quality and financial issues.

6) Cultural Risks

These can be caused by a business's cultural tendency to hide or delay negative information. Such businesses are generally slower to react when impacted by unexpected events (Queenland, 2013). Risk is always associated to any supply chain, but by implementing a complete, proactive approach and by working together with your suppliers to define a strategy based on shared business goals, you will be able to reduce your exposure to risk and the catastrophic impact it can have. The best-laid strategies require your team to shift their mind-

set, to divide their attention equally between cost-reduction efforts and risk mitigation considerations, but the rewards are well worth the effort (Lawton, 2007).

2.7 Risks Assessment Methods

Risk assessment is one of the most important steps of the risk management process, the better the risk is assessed, the better the solution is provided. There are different risk assessment methods proposed by many researchers, but these methods differ in different organizations and businesses and risk managers should adopt the ones, which suit best for their business. Below are some of the common risk assessment methods.

I. FMEA (failure mode and effect analysis)

Started in 1940s by the US military, failure mode effects analysis (FMEA) is a systematic proactive approach to identify all failures in a manufacturing, design, assembly process, or in a product or service (ASQ, 2021). FMEA's structured approach pinpoints the potential failures and has two broad categories 1. Design FMEA (DFMEA) and 2. Process FMEA (PFMEA) (Irene, 2020). This method is used for evaluating a process to identify how and where it could fail and what could be the impact of the failures, the method functions in 3 steps a. Failure modes (what could go wrong?), b. Failure causes (why would the failure happens?) c. Failure effects (what could be the consequences of each failure?) (Ihi, 2021). The FMEA identifies the effects of those failures, and provides a structure for revising the design to mitigate risk where necessary, this is an inductive process, and questions should be asked throughout process, "if this failure occurred, then what could happen? FMEA is performed in the following steps (Cyders, 2014).

- Identify modes of failure (what is the failure?)
- Identify consequences and related systems for each mode
- Rate the severity (S) of each effect
- Identify potential root cause for each failure mode
- Rate the probability of occurrence (O) of each root cause
- Identify process controls and indicators
- Rate detectability (D) of each mode/root cause
- Calculate risk priority (S*O*D)
- Use design to mitigate high risk or high critical failures and re-assess the processes to mitigate the risks

The outcome of the FMEA assessment is an RPN (risk priority number) and this number shows the priority of the risk which needs to be mitigated, the higher the RPN number the higher the priority; the RPN is calculated (RPN = Severity * Occurrence * Detection). The Severity in RPN calculation shows, how severe the impact of the failure could be, and the severity of the failure mode is ranked from 1 to 10 on a scale. The occurrence gives the information, how often could a failure occur? The potential of failure occurrence is also rated from 1 to 10 on a scale. The detection provides the information, how likely is it to detect a failure mode? The capability of failure detection is also ranked from 1 to 10 on scale. FMEA traditionally uses a 10 points scale where high numbers are bad, these are (1. None, 2. Very Minor, 3. Minor, 4. Very Low, 5. Low, 6. Moderate, 7. High, 8. Very High, 9. Hazardous with warning, 10. Hazardous without warning).

The FMEA approach is used in a wide range of industries i.e., software development, manufacturing, transport and logistics, healthcare, agriculture etc. This is a good approach for risk assessment, but it is not in scope of this research.

II. PPRR model (Prevention, Preparedness, Response, Recovery)

The PPRR model is a comprehensive and effective approach to risk management. This model has a successful track record and has been used by Australian emergency management agencies for decades and can be beneficial for any organization to save your business money and time when responding to a setback, disaster, or incident. The PPRR model can be used to minimize the losses in the event of an incident; it can help to anticipate the possible direct impacts on your business, suppliers, and customers (Queenland, 2021). Below figure 2.9 shows the PPRR model in details.

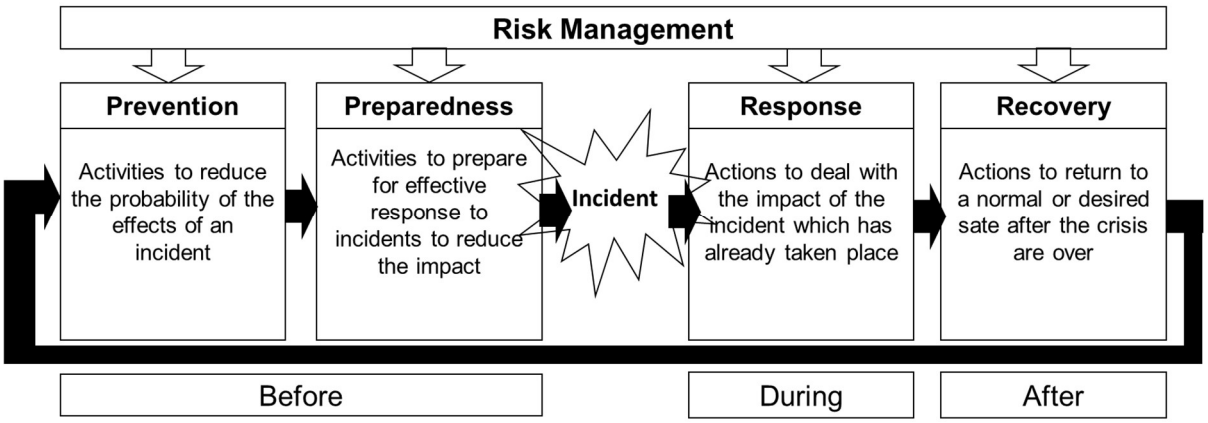


Figure. 2.9. The PPRR model: figure based on (Belkacem, 2020) *with modifications*

The PPRR model includes the following steps (Queenland, 2021).

- Prevention: In this step, actions have to be taken to reduce or eliminate the likelihood or effects of any incident on your business; these actions could be proper risk management plans.
- Preparedness: In this step, measures have to be taken before an incident occurs to ensure effective response and recovery, these could be achieved by conducting business impact analysis.
- Response: This step contains an incident response plan to control, mitigate or minimize the impact of an incident.
- Recovery: This step includes a recovery plan to minimize the disruption and recovery times.

This model works very well in crisis management related to natural disasters; this approach is also not in scope of my research.

III. Bowtie Method

Bowtie method is a risk evaluation concept, which is used to help the planners to analyse risks and the consequences of these risks as well as preventions and mitigation factors of different planning decisions in a structured way (Broadleaf, 2019). Figure 2.10 shows a typical Bowtie model.

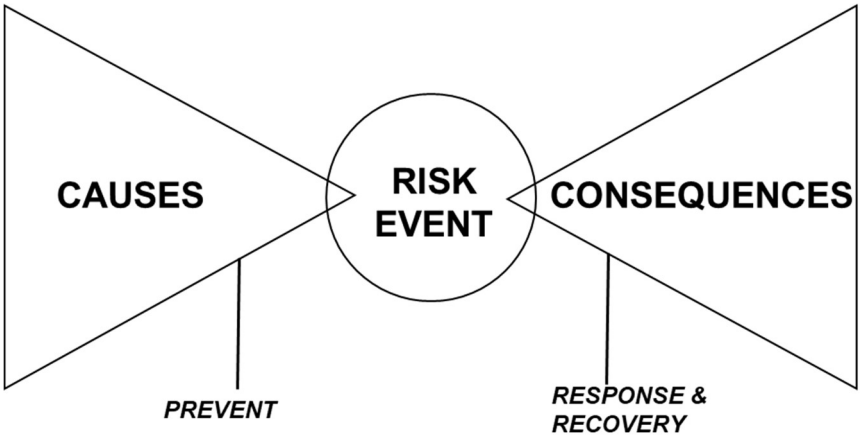


Figure. 2.10. The Bowtie model: figure based on (Ruijter, 2016) *with modifications*

A bowtie diagram is a shape like bowtie with the causes of risk on one side and the consequences on the other side and the risk event in the centre. Unlike a tabular risk register, there are no numbers or values in the analysis; it is a visual way of describing, linking, and analysing the pathway of the risk from its causes to consequences. It simply helps the businesses to understand the relationships between causes of the risk, the risk event, and the consequences. Once the causes and consequences are documented, then preventive controls to stop the risk are put in place and similarly, response and recovery strategies are identified to minimize the consequences in case a risk even occurs. Although the bowtie method is getting popularity, but it lacks a consistent approach (Ruijter, 2016), that is why this method is not in scope of this research.

IV. What – If Analysis

What-if Analysis is a concept, which can be used for structured brainstorming to identify what can go wrong in a given scenario. In this concept the values of specific or many parameters are changed in a calculation to judge the likelihood and consequences of that change (ACS, 2020). What-if analysis provides an opportunity to the organizations to explore multiple scenario options, compares outcomes of different alterative options and finally selects the better option. The What- If Analysis works in the following steps (ACS, 2020).

- Team kick-off
- Generate What-if questions
- Risk evaluation and assessment
- Recommendation development
- Setting priorities
- Assign follow up actions

Although this concept is easy to use and does not require any specialized tools, still it cannot be used in my area of research, because it is useful only when the right questions are identified. It relies mostly on the intuition of the team members; it is more subjective than other methods. Instead in my research, I have used the concept of Monte Carlo simulation to define different scenarios in a more structured way.

Chapter 3: Deep Dive in Procurement

Procurement is considered as an important part of supply chain and the value it could bring to any supply chain should not be under-estimated. In this chapter, a detailed overview of procurement and its importance in any supply chain is presented, also the misconceptions regarding procurement and purchasing have been addressed.

3.1 Procurement vs Purchasing

Many people use the terms procurement and purchasing as identical, these terms do have similarities, but they are not the same, this is clarified with the following definition. Purchasing is a narrow and simple function in any organization, and it means to buy something for a specific price, while procurement has a wider domain and includes the entire process through which resources; services, people, facilities, and material for any project are obtained (Academy, 2019). Figure 3.1 shows how purchasing is one part of procurement.

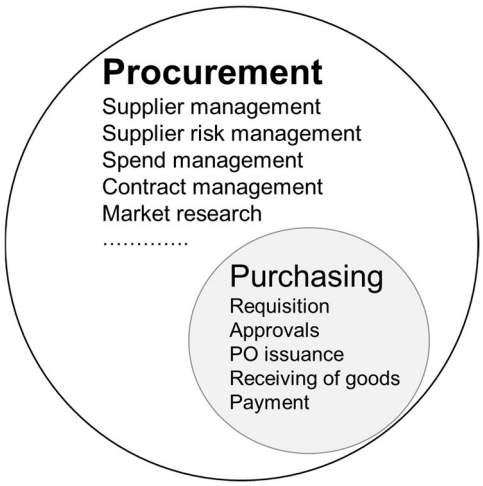


Figure 3.1. Procurement vs Purchasing (own content)

Purchasing is simply the operational part of the overall procurement processes or in other words it is the process of ordering goods and their payment. Procurement is used to satisfy the needs of business sectors as well as governmental sectors. The procurement processes which deal with governments is called public procurement.

3.2 Public Procurement

Public procurement also referred as government procurement is the procurement of goods, services, labour, and construction on behalf of a public authority from a private sector. The range of this procurement varies from government to government, but the bottom line remains the same, which is to provide proper services and facilities to its citizens. Governments establish contacts with private sectors to supply goods and services for construction of roads, hospitals, schools, public buildings etc. (Djankov, 2016). Public procurement is the necessity of time, as governments cannot produce all goods by themselves to achieve their targets. Public procurement is a 4.2 trillion business making it prone to many risks, where the risk of corruption has the highest probability to occur. Public procurements are mostly large and include complex procurement processes because of the involvement of civil servants and

politicians (Oecd, 2016). Fraud and corruption in public procurement increases the overall costs and compromised quality of the products. The OECD foreign bribery report in 2014 makes it evident that public procurement is prone to corruption in comparison to other bribery factors (Oecd, 2014). Figure 3.2 shows more in details of the bribery report of OECD.

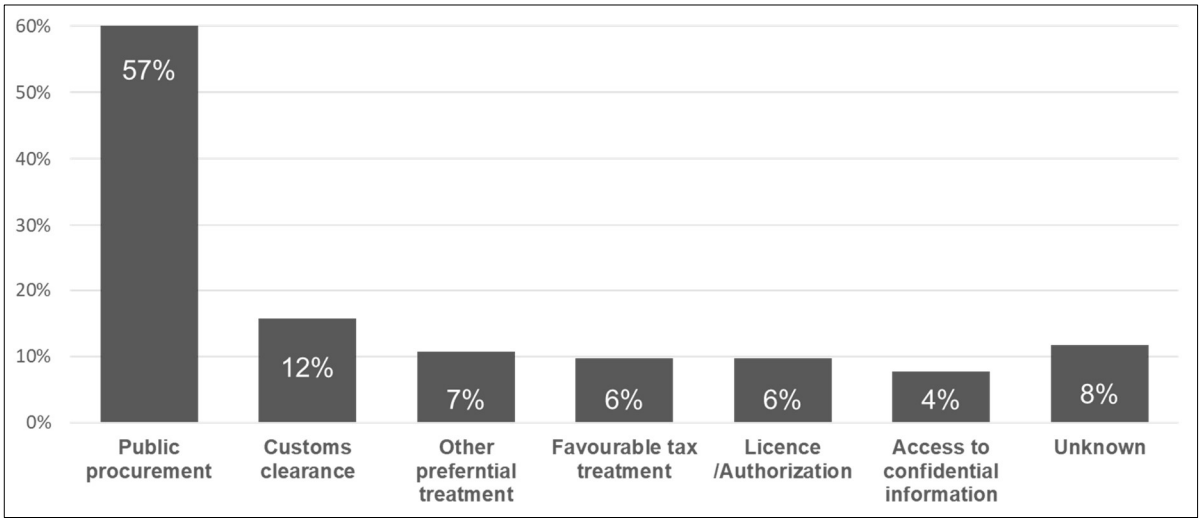


Figure 3.2. OECD bribery report 2014: figure based on (Oecd, 2014) *with modifications*

In order to prevent corruption, transparency within the procurement processes should be ensured and digitization must be implemented.

3.3 Procurement and its Types

Procurement is defined as the action of acquiring goods, services or works from an external source. It is a process in which two or more parties find and agree on terms and conditions, how these goods, services and works are going to be transferred. Different authors and experts divide procurement into two types, but in this research, the procurement processes are divided into three types to achieve the targets of automation of each procurement type.

3.3.1 Strategic Procurement

It is one of the most important procurement type and is also known as P2S (Plan to Strategy), it refers to long term organization-wide plans to ensure timely supply of goods and services which are crucial and critical for the business (Business, 2017), on the other hand it also focuses to reduce suppliers, identifying critical suppliers and maintaining long term relationships with strategic suppliers (CIPS, 2009).

This type of procurement should be undoubtedly considered as the most important type of procurement, it deals with the overall strategic topics and has the biggest impact on cost-saving and customer satisfaction. The typical steps of a P2S process are shown in figure 3.3. The processes do not have a specific order to be followed but they are inter-dependent on each other and they could be executed as one process to bring more value to an organization.

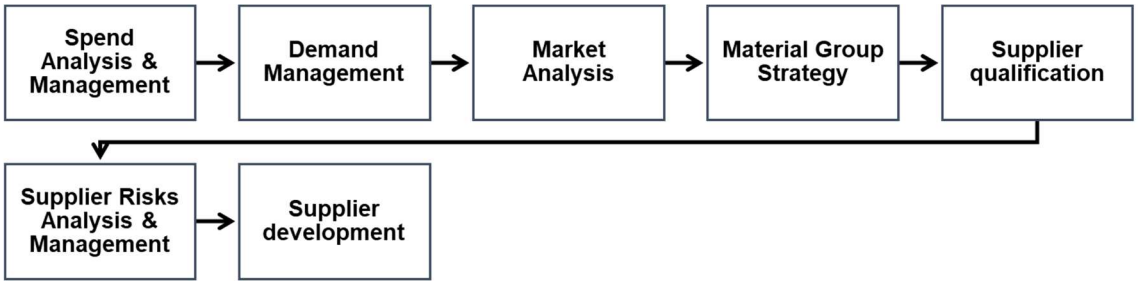


Figure 3.3. Typical strategic procurement process: figure based on (amc, 2017)*&* (Rendon, 2005) *with modifications*

3.3.2 Tactical Procurement

Tactical procurement refers to the short-term plans up to 1 year and transactional activities to keep the business running smoothly (Vecchio, 2021). This type of procurement is also a vital part of procurement and involves the following steps

- Requirement specification
- Invitation of tenders
- Negotiation (auctions)
- Contract creation
- Contract management
- Supplier evaluation
- Supplier data management.

Tactical Procurement, also known as “Source to Contract” S2C is the process of procurement, which starts from the requirement identification and ends with a complete contract with suppliers. The process steps involved in the process are deeply dependent on each other and if one of the process steps is executed improperly, it would have a negative impact on the overall strategy.

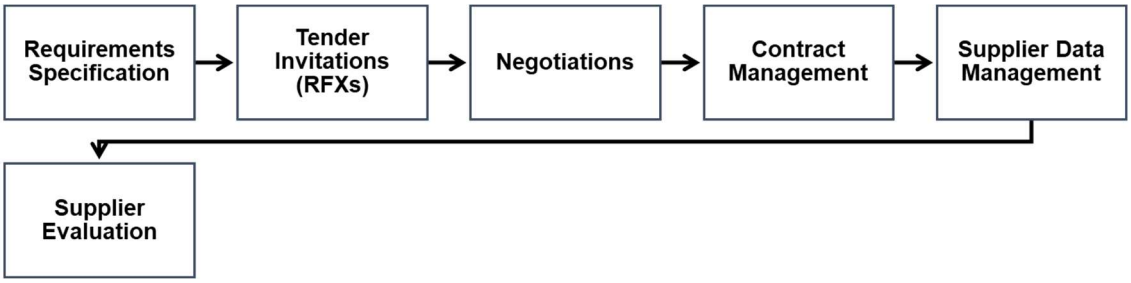


Figure 3.4. Typical tactical procurement process: figure based on (amc, 2017) *&* (Procurement, 2012) *with modifications*

A typical traditional tactical procurement process includes a lot of manual tasks and events, it also includes many repetitive and small tasks and above all, a proper communication must be done at any given time with the suppliers (Claritum, 2018). The manual procurement process involves a lot of manual documentation processes which requires a lot of space for document storage that could be prone to damage, loss, and theft (Bowers, 2017).

In the modern times, most of the companies are still using the conventional S2C processes even though the digitization would eliminate the conventional procurement methods with the passage of time (Leonard, 2013). According to a survey from SAP most of the procurement leaders are of the opinion that the digital transformation would affect the supply chains because many of the companies are still not ready to change, on the other hand there are very small number of companies which are already in the process to digitize their procurement processes (Vollmer, 2018).

Automation concept for tactical procurement processes is discussed in detail in the following chapters as the purpose of the research is to automate all the procurement processes.

3.3.3 Operational Procurement

Operational procurement commonly known as P2P (Procure to pay) or R2P (Requisition to pay), is the process of requisitioning, purchasing, receiving, and paying for the good or services needed. This process is the actual purchasing process of the procurement. The name comes from the ordered sequence of procurement and the financial processes, starting with the first steps of procuring goods or services to the final steps of paying for it (Rouse, 2012). Operational procurement deals with the orders after a contract has been set, and it works for the daily purchasing needs of an organization. It involves buying goods and services for an organization, managing deliveries, contracts and finally dealing with complaints if needed (Lin, 2017). A typical “procure to pay” process is shown in the figure 3.5. below.

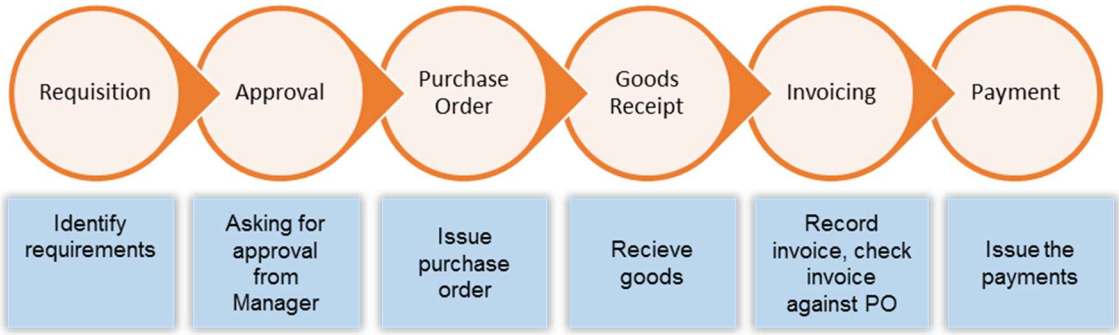


Figure 3.5. Conventional “procure to pay” (P2P/R2P) process: figure based on (procuredesk, 2019) *&* (amc, 2017) *with modifications*

A typical traditional operational procurement process includes a lot of manual tasks and events, it also includes many repetitive and small tasks i.e., identifying requirements, approvals, issuance of purchase orders, payments etc., and further, a proper follow up and communication with suppliers (Claritum, 2018). Most of the businesses in the digital era are still using the conventional P2P process to meet their operational procurement needs, knowing the fact that the digital revolution is eradicating the conventional procurement methods. This ignorance is one of the most prominent risk associated with operational procurement. Indeed, it is hard to understand that still the P2P automation to mitigate its risks by significant improvements with speed and accuracy is still under radar for so long (Leonard, 2013). It is the role of procurement to transform the traditional procure-to-pay processes into cost-saving and transparent strategic approach (Ashok, 2018). Automation of operational procurement process is presented in detail in chapter 5.

3.4 Importance of Procurement in Supply chain Management

Procurement is an important part of supply chain management although it has not got much attention in comparison to other parts of supply chain management, but procurement should also be taken more seriously, and its processes need to be improved with the passage of time and with digitization. The success of any organization is dependent on the procurement processes. Procurement does not only deal with buying goods and services for any organization, but rather it manages the whole parties, suppliers, contracts, spend related to the goods and services bought for any business. If procurement of an organization is not performing well, it would have an impact on the overall performance of supply chain and if the procurement is in the right direction, it would result in great cost savings and increase the overall performance of supply chain. Figure 3.6 shows procurement as the vital part of supply chain.

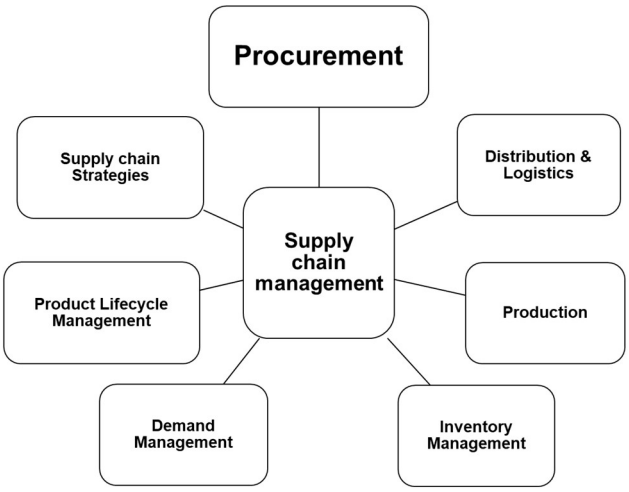


Figure 3.6. Procurement as part of supply chain: figure designed based on (Kunj, 2018) *&* (Cale, 2018) *with modifications*

3.5 KPI's in Procurement

"If you cannot measure it, you cannot improve it" – Lord Kelvin. This rule applies to every sector of the supply chain, and as procurement is one of the most important part of supply chain, this rule applies to procurement as well. As mentioned above, procurement is no longer the simple a source- to-pay cycle, it is more than that and plays an important part in the business growth strategy. In today's competitive world, procurement departments remain under immense pressure to deliver value beyond savings; businesses are looking for opportunities where they can improve the performance and efficiency of their procurement processes and making it more sustainable. Nevertheless, to achieve these goals, crucial decisions have to be made on the right data and information (Writer, 2021). In order to measure the performance of the procurement, it is important to define some basic general KPIs (Key Performance Indicators). KPIs are more than just normal indicators, they form a strategic matrix/scorecard to manage procurement (Brial, 2021). KPIs in procurement help in monitoring and controlling the

performance of the procurement in any organization. As different companies have different business priorities and goals, therefore the procurement does not operate in the same way.

Different research scholars and businesses have proposed different KPIs to keep the procurement on track, but in my research, I have highlighted below the areas of KPIs which could be applied to almost all procurement in all business industries.

- Savings
- Number of suppliers
- Compliance rate
- Spend management
- Spend under management
- Procurement ROI (return on investment)
- Supplier Lead Time
- Purchase order accuracy
- PO cycle time
- Cost per order
- Price competitiveness
- Rate of emergency purchases

3.6 Procurement's Contribution to Company's Performance

The contribution which procurement could bring to any organization is not a hidden truth anymore, procurement deals with money and money is the most important factor for any organization. However, the prerequisite is that the organization should have a proper procurement setup in place. Almost in all organizations the spend is divided into 2 categories a. CAPEX (capital expenditure) and b. OPEX (operational expenditure) and it is the responsibility of the procurement department to handle both these spend types separately and properly to achieve the companies saving targets. CAPEX is the money, which is spent by the organization to maintain, buy, or improve its fixed assets, i.e., land, buildings, equipment, intellectual property assets, vehicles etc. and which are intended for long term. While OPEX are the expenses that organizations spend to run the day-to-day business i.e., salaries, consultancy services, maintenance, rent, and repairs etc.

Procurement contributes to the strategic, tactical as well as the operational processes of the organization, that is how it generates one-off as well recurring savings for organizations. The figures given below give a clear overview of how procurement contributes in different ways to organizational performance.

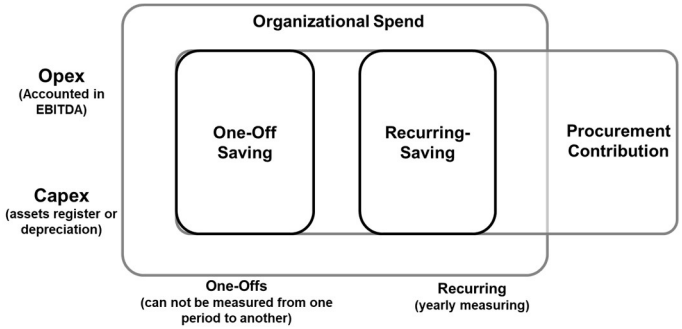


Figure 3.7. Procurement contribution in organizations (own content)

In addition to the saving contribution by procurement, figure 3.8 shows the value which procurement could bring to any organization in terms of risk management, make or buy decisions, spend transparency, supplier relationship management, speed to market, automation, and cost avoidance etc.

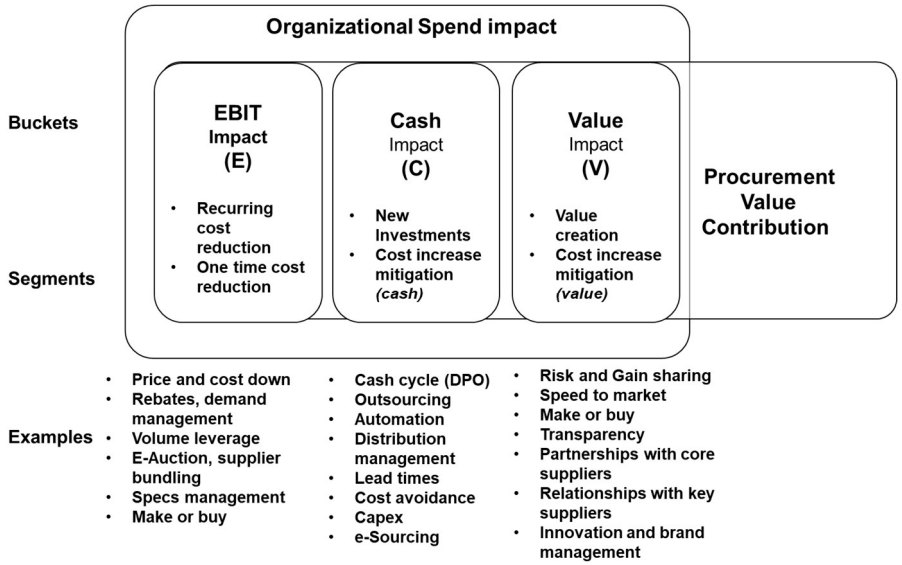


Figure 3.8. Procurement value contribution in organizations (own content)

The procurement value contribution in the figure above reflects the information regarding savings or cost reduction by procurement, which proves how much value a proper procurement department could bring to any organization.

3.7 Procurement Roles in Organizations

As procurement is a vital part of any supply chain, there must be a procurement department in any organization whether it is small, medium or a big size company. The roles or titles could vary from company to company. In contrast with old times, the procurement is taking attention in recent times. A set of roles are defined from strategic level to operational level in figure 3.9.

Position / Title	Procurement Level
CPO (Chief Procurement Officer)	Strategic
Procurement Director	Strategic
Category Manager	Strategic and Tactical
Sourcing Manager	Strategic and Tactical
Procurement Manager	Strategic, Tactical and Operational
Strategic Buyer	Strategic and Tactical
Buyer	Tactical and Operational
Operational Buyer	Operational
…..	……

Figure 3.9. Procurement roles in organizations (own content)

Procurement has a critical role in any supply chain; the digital technologies should be used to automate the procurement process in order to compete with the changing world. Procurement

is not only about purchasing products, goods, or services for any organization; rather it is the backbone of any organization and involves many important topics, which could lead organizations to climb the ladders of success. Procurement is transforming into a modern, digitized value driver and value creation partner for companies, departments, technology, and production. Clear objectives and measurable strategies are the foundation of every change – as well in procurement. Figure 3.10 shows the possible development of procurement with the growth in technology.

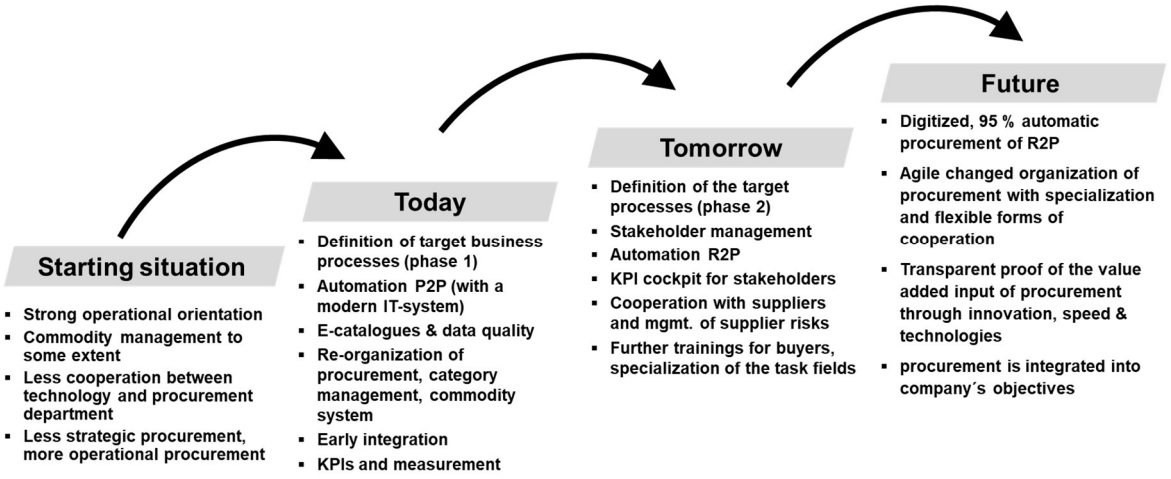


Figure 3.10. Possible procurement development with the growth in technology (own content)

The automation of procurement is the demand of time and companies have to invest seriously in order to achieve their goals and stay long in the business, but clear objectives and measurable strategies are the foundation change in procurement. Future procurement should combine agile structures and working methods to achieve a high degree of performance for companies.

Chapter 4: Blockchain Based Supply Chain

In this chapter, the concept of a blockchain based supply chain has been presented. The aim is to investigate the research development in the field of supply chain risk management (SCRM) and to merge the new emerging digital technology of blockchain that could help to mitigate risks in supply chain.

The chapter also includes a deep dive in the blockchain technology and its application in different sectors. Blockchain technologies can have a potential to upgrade the conventional supply chains, that will increase the performance of supply chains in terms of speedy flow of raw material, finished goods, information, and money flow, and help to mitigate risks in supply chain by increasing visibility and transparency of supply chain. Smart contracts, IoT and Blockchain can serve together to achieve maximum efficiency and effectiveness in supply chain management.

4.1 Introduction to Blockchain

“Change is the law of life and those who look only to past, or present are certain to miss the future.” John F. Kennedy.

The blockchain technology is still in its developmental phase, therefore there is no uniform standard definition of blockchain, every author has defined it in his/her own way. Some of those definitions are: Blockchain is a peer-to-peer network that works on top of internet to transfer ownership of information with added value without using a central control (Lansiti, 2017). Blockchain is a special form of distributed ledger technology with some extra feature to serve as database. The database is distributed and shared amongst the stakeholders in an encrypted form. Blockchain is tamperproof, irreversible, and hacking proof (Wright, 2017).

(Glaser, 2017) defines blockchain conceptually as a peer-to-peer network that stores data on every node of a database, which is transparent and distributed.

Nakamoto first used blockchain in 2008 as the basis of Bitcoin transaction (Nakamoto, 2008). Since then, a lot of researchers and users are taking interest in the use of blockchain globally. Many of the researchers are convinced, that it has a potential to change many domains comprehensively (Beck, 2018). In 2021 the world observed a historical hype in Bitcoin, which is a crypto currency and is based on the blockchain technology.

There are three possible structures of any network, namely

- Centralized
- Decentralized
- Distributed

Blockchain is based on distributed network in which each node can have access to every other node and exchange data; these nodes are connected through internet. It can also work decentralised when some nodes are inactive.

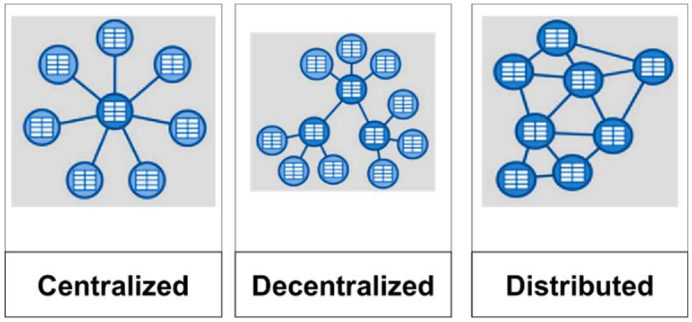


Figure 4.1. Types of network distribution: figure based on (Killeen, 2015) with modifications

A node can be any computing device with storage and an internet connection. Each node has an identical copy of blockchain which is automatically downloaded when a node enters the network. When a node records any transaction, it is transferred to all the other nodes in the network via internet. After a consensus mechanism, the transaction is approved, encrypted with hash functions, and recorded with time stamps in the form of block, once the block is attached to the chain, it is no longer possible to reverse it (Swan, 2015).

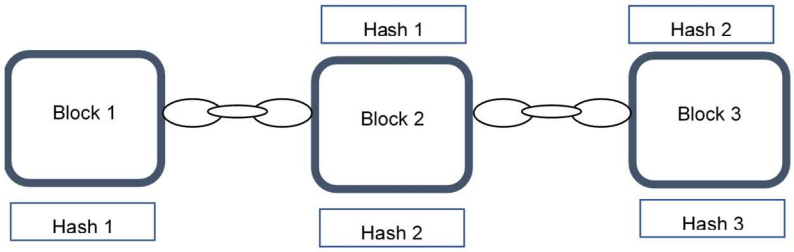


Figure 4.2. Block connected by hash header and footer: figure based on (Lewis, 2015) *with modifications*

A blockchain records information in blocks and uses cryptography to chain these blocks in a chronological order or a sequence i.e., each block can be traced back using its hash number (Schweizer, 2017). During generation of a block, each or selected nodes can use consensus method to approve block to add in a blockchain (Glaser, 2017). The functions of blockchain do not need central authority to control the database. The idea behind a blockchain is disruptive, powerful, and innovative, it has a potential to transform many services and improve the productivity with a large range of applications (Hancock, 2016).

4.2 Blockchain Operations

Blockchain operation is illustrated in detail in the figure 4.3. In the first step of operations, there is a need to transfer money from “A” to “B” which creates a transaction. The transaction is broadcasted to the nodes of the entire network. After validation, the transaction is added to new block. A new block generated needs to be approved in order to be added into the chain of blocks. Once the block is approved, it is added to the blockchain. The transaction is executed, and the money is transferred from “A” to “B”. Figure 4.3 shows the illustration of a blockchain transaction.

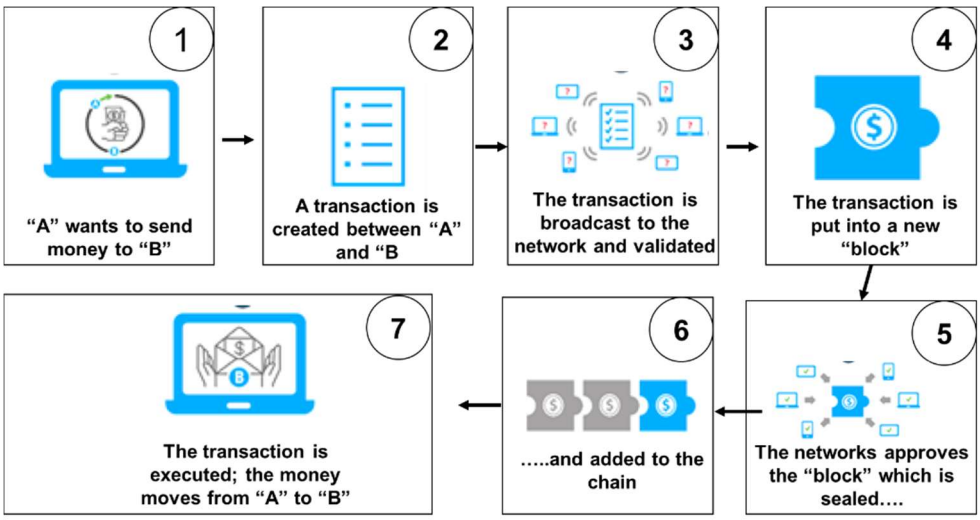


Figure 4.3. Illustration of blockchain transaction: figure based on (Accenture, 2018) with modifications

Blockchain is moving from discussion to use-cases development, due to the reason, many practical business models are being developed with passage of time. Traditional enterprises are investing more time and effort in blockchain as compared to other development programs, to enhance efficiency, business model innovation and to create revenue resources (Pawczuk, 2018). In order to understand blockchain application scenarios and to discover its real potential, businesses must use the indigenous capabilities of blockchain. These capabilities are presented in figure 4.4. The capability "secure" is based on cryptography, which makes the blockchain immune to fraud. Second capability of blockchain is the shared information across the network, this capability is used when there is need to share data across multiple internal and external organizations. Distributed and ledger capabilities are needed to record the data in ledger and to finalize it, further the data is distributed across the entire network which makes it harder to change (Junco, 2017).

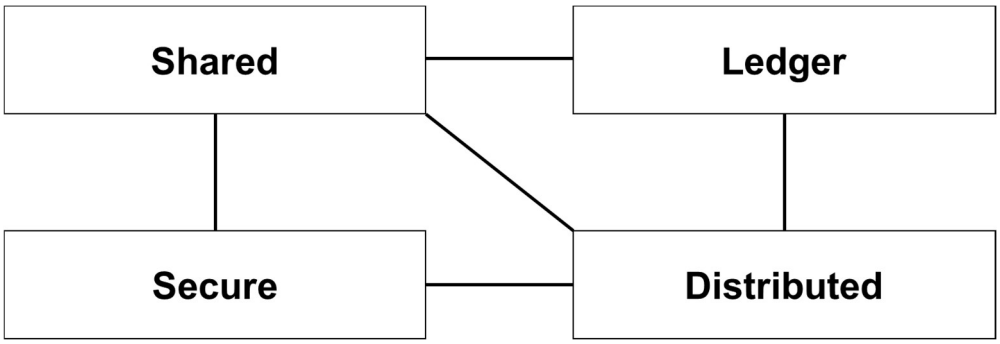


Figure 4.4: Blockchain capabilities: figure based on (Junco, 2017) with modifications

Blockchain is secure because it uses strong cryptography to create transactions which are strong enough to prevent fraud and provides a shared truth. All these transactions are signed using digital certificates, making them transparent. The vital benefits of a blockchain in

comparison to a conventional technology can only be achieved when the organizations are linked to share information.

4.3 Types of Blockchain

First developed blockchain was public, everyone could download and use it. All the users had the rights to see all the transactions without permission. With the evolution of blockchain technology the use of blockchain is restricted to the concerned users because, information like, goods transportation in supply chain or medical information of a person, cannot be publicly disclosed (Kakavand, 2017). Although there are 4 types of blockchain, but according to (Lin, 2017) blockchain can be divided in to three main categories depending on organizational requirements of use.

I. Public blockchain
II. Private blockchain
III. Consortium blockchain

I. Public Blockchain

Public blockchain is referred to as a blockchain which is free to be accessed and transactions could be inserted. The users have the authority to verify the transactions of other users and they can participate in consensus. Anyone with an internet connection and a computing device can enter a public blockchain. The public blockchains are open to everyone and do not require permissions to be accessed. Some important examples of this type of blockchain are Bitcoin blockchain and Ethereum (Lin, 2017).

II. Private Blockchain

Contrary to a public blockchain, the private is not open for everyone. Participant nodes are limited to only authorised users. Every new entering node in private blockchain needs a permission from all other members, who are already in blockchain. This feature allows the flow of data to be limited to the members only and fulfils the privacy aspect, making it useful for private organizations as well. This is also referred as enterprise blockchain (Voshmgir, 2016). Every member of the enterprise is assigned with a node after disclosing their names and designations, allowing them to share data on this decentralised database. This provides high level of data security and transparency within organisation. Validation system of a private blockchain can be simple, cost-effective, and fast. Private blockchains are also simple and fast to adapt with the help of software through minor changes (Meinel, 2018).

III. Consortium Blockchain

Consortium blockchain can be either public or private blockchain but only some pre-selected nodes can validate the transactions. This group of nodes can only participate in consensus and control the access to history of blockchain (Buterin, 2015). This is contradictory with the basic idea of blockchain that protocol is open and for everyone. But as validation or consensus process of this blockchain is slow and expensive, this type of blockchain provides the solution which is partly decentralized. Some industries are developing consortium blockchain like Hyperledger (Lin, 2017).

4.4 Blockchain Decision Path

Each type of blockchain has different application areas where they have certain benefits and drawbacks. Many researchers have worked on blockchain decision path via set of key questions to conclude which type of blockchain suits or even if there is need of a blockchain at all in a specific situation. (Wagenaarm, 2018) in his research presented blockchain decision path as shown in figure 4.5 to identify blockchain suitable from private, consortium and public blockchain or if a blockchain is needed at all. In case of businesses where confidential data is involved, public blockchains are not suitable, only consortium blockchains can serve the purpose.

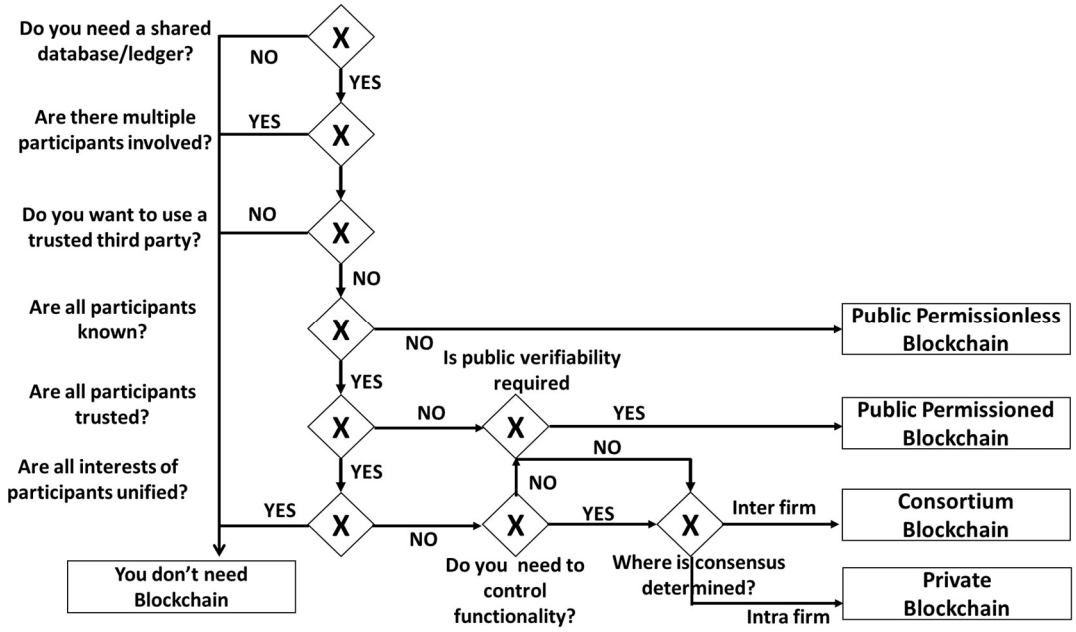


Figure 4.5. Blockchain decision path: figure based on (Devopedia, 2018) & (Wagenaarm, 2018) with modifications

4.5 Blockchain Terminologies

In blockchain, there are many terminologies used, but the one which is related to the research is discussed below.

▪ Consensus Mechanism

There are numerous consensus algorithms available and blockchain developers can select an algorithm depending on performance and use of resources like energy needed, speed and security level (Christidis, 2016). The consensus mechanism ensures that all nodes agree on same message and new block is correctly added. There are numerous consensus algorithms developed. Following is a list of common algorithms proposed by (Anwar, 2018) used in different blockchains.

- Proof-of-Work
- Proof-of-Stake

- Delegated Proof-of-Stake
- Leased Proof-Of-Stake
- Proof of Elapsed Time
- Practical Byzantine Fault Tolerance
- Simplified Byzantine Fault Tolerance
- Delegated Byzantine Fault Tolerance
- Directed Acyclic Graphs
- Proof-of-Activity
- Proof-of-Importance
- Proof-of-Capacity
- Proof-of-Burn
- Proof-of-Weight

4.6 Internet of Things and Blockchain

Internet of things (IoT) is the technology, which provides a platform of communication between different machines without the involvement of human. The machines can communicate, exchange data, commands, and information with each other. Blockchain can record and secure data cryptographically making it protected from reversing and changes. An IoT device can be used in a supply chain e.g., in a warehouse or a smart container where the IoT can store information regarding temperature or location (Dorri, 2017), this information can be transferred to a blockchain from the IoT device.

The information on blockchain will be secured and shared decentralized including the information regarding the state and status of packages, pallets stored in the container during transportation and match them against the agreed contractual terms (Puthal, 2017) (Ray, 2018). Smart contracts can also be integrated to execute terms of contracts, for example a change in the temperature during the transportation of consumable products for a certain period will make them compromised and are of no use for the company which ordered them (Puthal, 2018).

Conventional devices when connected with IoT are capable to work smartly and can take decision autonomously. Blockchain is the key digitization technology which has transformed the information sharing concept by making it more secure and decentralized. The internet of things (IoT) was first used by Wireless Sensors Network (WSN) technology which is now evolved to Radio Frequency Identification (RFID) that gives it the capacity to communicate the data via internet (Diaz, 2016), which gives it the freedom to be potentially used in any electronic device from a large hardware to wearables.

The IoT allows to interact and exchange data with each other like a virtually connected world which represents real world (Reyna, 2017). According to (Reyna, 2017) blockchain and IoT can interact in three ways. IoT-IoT interaction in which IoT has a possibility to communicate directly with each other as well as to send data to blockchain. Second interaction can be, that each IoT is connected to blockchain directly and exchange information via blockchain data. In this interaction method, data is stored in blockchain with the information of sender. Other possible interaction is a hybrid approach in which there is possibility to integrate other digitization technology.

IoT devices can be installed on containers which can enable the containers to communicate with other devices, these can be referred to as smart containers. A smart container can be traced with GPS in real-time allowing more customer satisfaction. Furthermore, it is connected with entities of container terminal and shares information to custom authorities.

Following information can be digitally integrated in smart container

- Location of container
- Contents of container
- Condition of container i.e., temperature, damage etc.
- Destination of container
- Transporting schedule
- Transporting history

A combination of IoT and supply chain management can be achieved by adding a digital tag, which is an equipment with built-in smart chip. The digital tag can communicate its ownership, warranties, contents, location, or any other special data and the blockchain can store the data with integrity and efficiency (Tapscott, 2016). Many companies are already working to connect IoT and blockchains, and in the year 2019, IBM won the “NexGen supply chain leadership award for blockchain and IoT” (NextGen, 2019). Supply chain transformation is an initiative of IBM to focus on transformation of future supply chain with the use of blockchain. IoT blockchain in supply chain can provide the traceability of products throughout the product life cycle and possibility to track products in real time. In addition, digitization of processes will reduce the risk of possible delays in receiving original papers associated with transportation of goods. Moreover, the digitization will provide the visibility of products in various phases such as “product life cycle management” and “supply chain risk management” (IBM, 2019).

4.7 Applications of Blockchain

(Lansiti, 2017) predicts, that there is a strong possibility that the blockchain technology will affect businesses, but the question is “when” exactly.

Numerous potential applications of blockchain technology are already known and more applications should be explored associated with this innovative distributed database system. The applications which have been developed based on blockchain are generally divided into two basic categories i.e., Financial and Non-financial.

I. Financial

First application of blockchain technology was in the financial sector, which gained a lot of interest to explore its benefits. Bitcoin is a first cryptocurrency developed with the blockchain technology and after the success of Bitcoin, many more cryptocurrencies are developed.

Other than cryptocurrencies, the blockchain technology is used to explore other financial activities under the term FinTech. Blockchain is one of the technologies, which has changed the traditional concept of financial processes. A lot of banks are also exploring the benefit of blockchain to improve their processes. Most of the world’s leading banks have collaborated to explore blockchain technologies (Kelly, 2015).

II. Non-Financial

Blockchain technology can also be used in the non-financial sectors. (Mougayar, 2016) have listed some blockchain-based services which governments can offer to its citizens, which are listed below.

- Registering marriage contracts
- Democratic voting system
- Record of landowners
- Ownership rights
- Intellectual property rights (Patents, Copyrights, etc.)
- Biding in procurement
- Vehicle registration
- Digital identity passports
- Driving licences
- E-residency
- Notary services
- Medical information
- Voting

(Burger, 2017) in their research have explored technical, legal, and policy implications of e-Residency and blockchain. Estonia has offered its virtual residency services in 2014 and is the first country in the world to provide digital residency to engage international residents in commercial activities (Gilbert, 2018). Blockchain technology can also be used in "notary service", which can verify authenticity of the document without the involvement of any central authority. Blockchain offers another service called "Proof of Existence", which provides a document certification service that helps to recognize the proof of ownership of a document, where it records the author details, specific time of creation of the document through timestamps and provides the integrity and authenticity of the document.

4.8 Blockchain Platforms

After the crypto bull-run in 2021 there are many block chain platforms available besides Bitcoin, but below are two most popular blockchain platforms which seems quite successful and provides many facilities.

1) Ethereum

Ethereum is a blockchain platform, which is open source and offers virtual machine, which is decentralized in nature and provides base to run smart contracts on blockchain. This virtual machine is known as Ethereum virtual machine (EMV). It also has its own cryptocurrency called Ethereum (ETH). It offers opportunity for anyone to write different types of decentralized applications, smart contract codes or other blockchain services (Watanabe, 2016). Ethereum is based on original technology used in bitcoin. In late 2013, Vitalik Buterin wrote a whitepaper, which presented a new and improved way of using blockchain technology. Ethereum blockchain is the improved version of Bitcoin blockchain, containing many of its features but different in blockchain architecture. Ethereum goes further as compared to Bitcoin blockchain in block containment, it adds copy of transaction and the most recent block in the blockchain (Vitalik, 2013).

Ethereum provides three basic types of applications. First is to connect contract with its financial applications giving more freedom to manage digital currencies. The second category is combination of digital currencies with non-monetary side. Lastly, there is also possibility to use it in non-financial applications like identity management (Vitalik, 2013).

2) Hyperledger

Linux Foundation in 2015 also started a blockchain platform with the focus of blockchain implementation in different businesses. Since then, Hyperledger has developed plenty of frameworks and tools to work and interact with blockchain. It focused on global businesses transactions including supply chain in order to improve connectivity, productivity, and reliability. It provides a base support for different core technicalities in blockchain (Liao, 2017). Hyperledger is a multiple organizational project, there are more than 50 members in this project (Cachin, 2016). The Hyperledger is currently offering these different frameworks like “Hyperledger Burrow” for smart contracts, “Hyperledger Fabric” for developing decentralized applications with consensus and membership services, “Hyperledger Grid” for supply chain solutions, “Hyperledger Indy” for decentralized identities and many other tools.

4.9 Smart Contract

Idea of smart contract was first presented by Nick Szabo in 1994 and is defined as “a computer programmed protocol that executes the agreed terms of a digital contract”. Idea was to write executable codes which contains clauses of contract, and these codes are stored on property that can autonomously implement these clauses. Resulting in minimizing or removing the need of third party’s mediation to enforce the terms of contract (Christidis, 2016). Smart contracts came more in practice with the development of blockchain technology; these smart contracts are translated into programmes and stored on the blockchain. Storage of this contract has a unique address by doing a transaction into this address that will execute this smart contract. Smart contracts allow blockchain to use functions and conditions beyond monetary exchange, for example validation of assets. Ethereum is the first ever blockchain which allows to use smart contracts (Buterin, 2013). After that a lot of smart contracts based blockchains are developed, “Hyperledger” is the most prominent amongst all. Smart contracts are ideally supported by blockchain, and some authors refer this version of blockchain as Blockchain 2.0. This new version of contracts has the potential to disrupt every type of business and more (Reyna, 2017).

Smart contracts inherit some basic benefits over normal working environment related to contacts for binding and its enforcement. Most prominent are accuracy, efficient operations, cost of operations and transparency of system etc., which allows its applications in multiple areas. Smart contracts are also vulnerable to security and operational risks because these are irreversible than communication failure between nodes; hacking, or viruses may lead to certain consequences (Reyna, 2017).

A Smart contract provides the possibility to execute a contract in much lesser time and gives a higher grade of flexibility over a short period time, which is not possible in traditional contracts. After successful execution of contract remittance can be transferred automatically which is cost efficient. Smart contract also gives freedom to sign contract without personal presence or posting original document from each party to other party. This also gives freedom to finalize a contract beyond traditional and international boundaries as it is done virtually only.

Decentralized operation of smart contract on blockchain does not need intermediator, as it executes autonomously, it obsoletes the need of lawyers (Hergueta, 2017). Below table shows some of the main differences between the conventional contracts vs. smart contracts.

Conventional contracts	Smart contracts
Time of contract is minimum one day	Contract is possible for short period of time i.e., for Minutes
Transactions are manually processed via banks	Automatic transfer of finances is possible
Lawyers are needed to enforce contract terms.	Lawyers are not necessarily required.
Contract needed to be physically signed and physical presence is necessary otherwise contract papers need to be shipped back and forth.	Contracts are virtually signed with in very short period.
Expensive in processing and enforcement	Cost efficient

Table 4.1 Conventional contracts vs smart contracts: figure based on (Hergueta, 2017) *with modifications*

4.10 Conventional Supply Chain Process

Within an international supply chain, there are a lot of operations involved and these operations are carried out by various organizations. Right after manufacturing, manufacturer itself or an intermediator exports the manufactured goods to international customers. During the transportation of the manufactured goods, a lot of paperwork such as export invoices, air waybills, packing lists, bill of lading, etc. are involved. Further the transportation is also not executed in one step, mostly intermodal transport is carried out to transfer goods across the globe, which further involves shipping companies to provide services on land and sea.

To shift the mode of transportation, loading and unloading services are also needed. These services are further subcontracted. Before loading and after unloading of products, authorities need to calculate custom charges in order to evaluate duties/taxes on the products. Moreover, insurance companies are also important stakeholders in the process, as most of the products are insured during the transportation, providing insurance claims for accidents during the transportation of goods.

All these processes need optimum control of information as the stakeholders need to be paid according to their services. In figure 4.6, the conventional practice of supply chain along with the flow of information and payments is presented. In the next heading, a blockchain based supply chain is proposed to improve the overall supply chain operations.

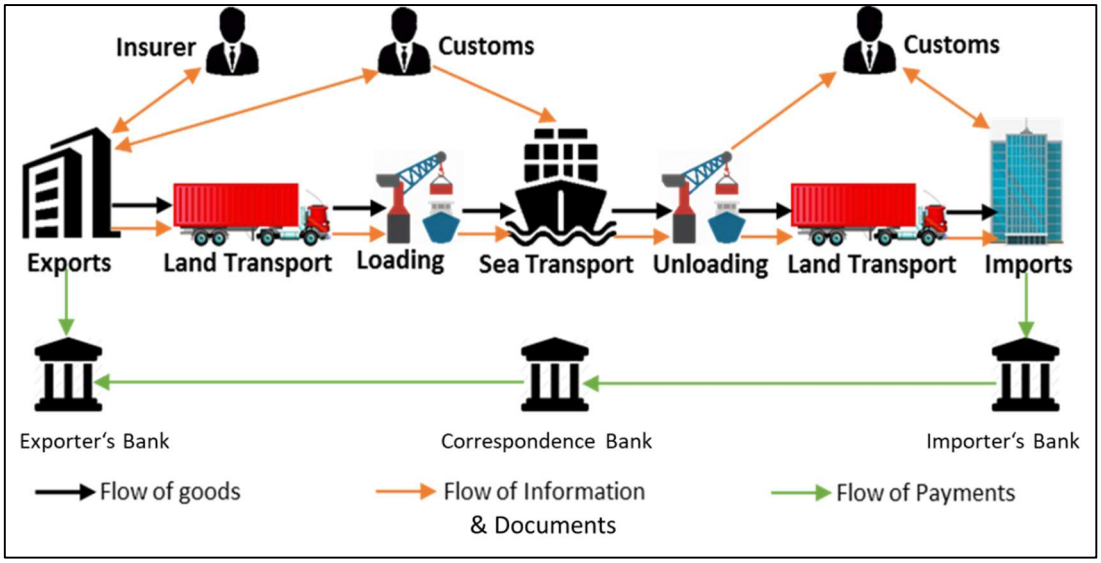


Figure 4.6. Conventional cycle of supply chain: figure based on (Parker, 2016) with modifications

4.11 Blockchain in Supply Chain

In 2016, first research paper was published on the use of blockchain technology in supply chain. The focus of this research was on the traceability system of food supply chain in china, which presented the idea of using radio frequency identification (RFID) technology with blockchain to record the agri-food supply chain (Tian, 2016).

In supply chain, the blockchain technology is in its developmental stage. Many private and public companies have developed test projects and many universities have established research labs for blockchain technologies like MIT, Duke, Cambridge, etc.

Other than this, governments are also involved to develop products using blockchain technology for governmental services. The USA government has taken IT initiatives on evaluation and adoption of blockchain in procurement as well as in many other areas (Administration, 2019). China has already established a committee for blockchain application for logistics and purchasing to work on standardization of blockchain technology (Buxbaum, 2017).

Port of Rotterdam, which is the largest port in Europe, has developed blockchain application for container logistics which transforms paper records to digital records (Jaacques, 2019).

The use of blockchain technology can be a game changer in the supply chain industry and can contribute to the overall success of the supply chain.

4.12 Proposed Blockchain-Based Supply Chain

With the introduction of new industrial revolution, industry 4.0, supply chain also needs to upgrade to match the core requirement of industry 4.0. This new version to supply chain may be called as supply chain 4.0. There are many digitization technologies, which can be integrated into supply chains to develop a fast, secure, transparent, and digital supply chain.

90% of world trade is carried out via oceans and millions of containers are moved globally (IBM, 2017). This transport generates a lot of paperwork for each shipment and involves many organizations, which needs a lot of communication.

Besides this, the conventional supply chains in the fast-moving containerized goods (FMCG) consist of many unclear situations, when the goods delivered to the customer are compromised because of temperature issues. The identification of the responsible party for the damage is always a challenge for the claims department of the customer because there are many parties and medium of transportation involved in the delivery of goods from the supplier to customer.

Blockchain technology has the ability, to integrate all elements of supply chain and record data in a decentralized manner. This provides transparency among the stakeholders with the ability to track all information, such as material, products, and finances. The increased transparency level provides a platform to trace the origin of products and complete life cycle of the product. The supply chains of today, must be sustainable and with the implementation of a blockchain, a high level of sustainability could be achieved.

In the proposed solution, shown in figure 4.7 a typical supply chain connected with blockchain has been presented. In the blockchain, a network of shipping companies, freight forwarders, seaports, shipping vessels and customs authorities are added. All the transactions between these stakeholders are managed on the blockchain. Smart contracts are also proposed to be used in the proposed solution, smart contracts in blockchain can execute transaction automatically without intermediators, which reduces the risk of fraudulent transactions and disputes between parties (Dujak, 2019).

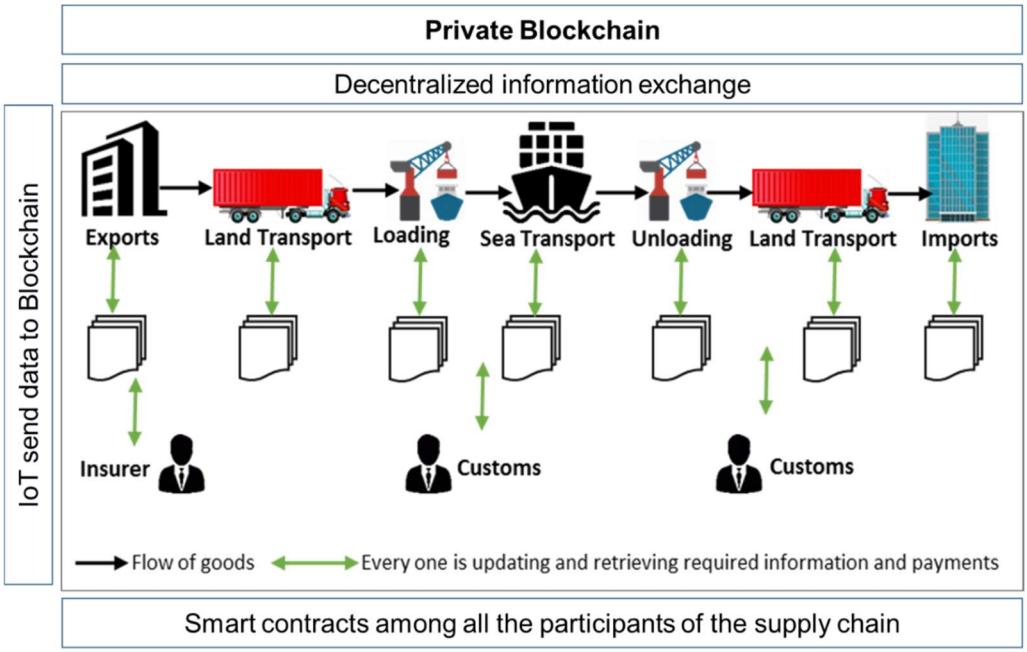


Figure 4.7. Possible supply chain using blockchain concept: figure based on (Luke, 2016) with modifications

With the use of blockchain in the proposed solution, the number of intermediators is reduced or even eliminated resulting vital reduction in operational costs. Blockchain involves the

concept of document sharing within the supply chain, this will improve the processing speed by reducing the waiting time and time needed to sort out information from original documents and labels. The proposed solution also provides the possibility to trace and track the products during complete supply chain from the beginning to the end as well as during transportation. The flow of products can be more visible with the use of blockchain technology which provides more control, flexibility, and optimized flow of product during complete supply chain.

The proposed solution also includes a concept taken from the research work of (Dujak, 2019) and (Christidis, 2016), who have categorised the blockchain properties into two main characteristics i.e., decentralized information exchange and automation of transactions. Both these characteristics have an important impact on logistics, supply chains and their networks.

According to (Dujak, 2019) the decentralized information exchange in blockchain is cryptographically secured, easy to access, trusted, verifiable and provides real-time information to every authorised member of the supply chain. According to (Christidis, 2016) the automation of transaction is possible with smart contracts, which execute an agreed set of instructions and can automatically verify the transactions.

In the proposed solution, the decentralized information exchange in combination with smart contracts is recommended. The smart contracts give extra feature to automate the transactions, which increases the overall benefits of the solution. Figure 4.8. shows a connection between the main characteristics of the proposed blockchain based supply chain solution and the benefits, which can be achieved with the proposed concept.

Characteristics of the Proposed Blockchain Based Supply Chain	**Benefits of the Proposed Concept**
Decentralized Information exchange (Secured, trusted, real time, verifiable, easy accessibility)	Traceability improvement Visibility improvement Improved demand forecasting Access of information Facilitation in paperwork Fraud prevention Automation in processing Operation of IoT in supply chain Catching counterfeit products Environmental monitoring Dispute resolution
Automation of transactions Using (smart contracts)	Fraud prevention Automation in processing Dispute resolution

Figure 4.8. Characteristics and benefits of the proposed solution: figure based on (Dujak, 2019)*,* (Petersen, 2017) *&* (Microsoft, 2018) *with modifications*

Future supply chains need to be faster, flexible, accurate and efficient. Faster in a sense to reduce overall delivery time, this is only possible by advanced forecasting approach for both external and internal data as well as status of supplies. Accurate and real-time information of supply chain is the demand of time, which should be more efficient (Mckinsey, 2016). The

proposed solution can bring many benefits to any supply chain; some of these benefits are presented below.

4.13 Benefits of Proposed Solution

The strengths of blockchain have an ability to affect every type of supply chain risk. Blockchain can provide an environment of trust within the entire supply chain by making everyone accountable for their own actions as it maintains records of each transaction of communication amongst the stakeholders in the supply chain.

I. Traceability Improvement

Traceability of the records is a plus point of the blockchain technology. Combination of new digitization technologies in supply chain can give the competitive superiority among competitors. Innovation in supply chain is needed to realize the benefit of new technologies (Lushcheuski, 2019).

Traceability of a product is very important, as it is directly related to the supply risk. If the origin of a product is traced and tracked accurately, it provides the exact manufacturing information about the product such as the place of production, the date of production and the suppliers involved.

Tracking the origin of products is important in FMCG supply chains, where it is important to keep records of the products, like which product is coming from which field and which fertilizers are used to grow them. Because of the tracking of products, if there are affected products in supply chain, they are timely identified and removed from the market.

In the manufacturing industry the traceability also plays a vital role, blockchain provides an excellent reference for tracing back the origin of raw materials used in the manufacturing of products. It also provides information, which supplier have produced the products and at which time. In Blockchain based supply chain, digital labels are used rather than traditional barcodes, which store and communicate information digitally.

For example, let us assume that we have a company ABC which operates in a blockchain based supply chain. Parts and components for an assembly line of the company ABC are sourced worldwide from 10 different suppliers, they are assembled at the location of company ABC and delivered to a customer. After delivery to the customer, a problem is detected in a part of the assembly. Due to strong traceability feature, it is possible to identify the supplier of the faulty part in relatively short time.

II. Visibility Improvement

Visibility is the key to have a strong control on managing the flow of goods in a supply chain. Supply chain is more visible when each movement of supply network is visible in real time. Due to a high visibility in the blockchain based supply chains, cost and service optimization is possible.

In a blockchain based supply chain, IoT devices can be installed on containers, pallets, or even packaging. The installation of the IoT devices on a container, turns a normal container to a smart container, which can communicate digitally with other devices and store all these communications on the blockchain.

Smart containers can easily be traced throughout the entire supply chain, making the supply chain highly visible, this real-time trackability of the containers reduces the supply risk of late arrivals.

High visibility can be extended to the production process, where, each process can be recorded on the blockchain, ensuring the quality assurance process to be more effective.

III. Improved Demand Forecasting

Demand management is an important part of supply chain and is based on forecasts. When the forecasting process is accurately managed, the supply risk of short production or over production are mitigated (Dujak, 2019). Forecasting always depend on the historical data of demands of a company, which is used to forecast for next periods. Accuracy of the forecast is based on the most recent and trusted historical data. Blockchain provides most recent data of a supply chain in real time and a trusted secured history up to the first block.

IV. Access of Information

The supply chains of today operate in collaborations to achieve maximum benefits, although the data exchange must be securely treated. Collaboration on blockchain to exchange data is very secure and efficient. Efficient and timely information exchange can reduce many risks associated with supply chain such as, inventory information at supplier's end or storage of products in a warehouse.

V. Facilitation in Paperwork

During containerized shipping, many documents are involved, which needs excessive paperwork from start until the end of the transportation which consumes a lot of time, effort, and money. Other than this, these documents are needed to be shipped in-original ahead of the shipment, so that these original documents can be presented on ports for port clearances. These documents of shipping trail are also risk prone i.e., loss of documents, fake documents or changed documents. The blockchain based supply chain almost eliminates the paperwork from the process, because every stakeholder involved in the shipment has access to the blocks of the blockchain, where all the information is present in real time and is authentic.

VI. Fraud Prevention

The blockchain based supply chain provides the verification of source, origin, or authenticity of the product, which prevents the fraud of fake products. Production information of the product can be stored on the blockchain with their unique identifications, which later provides reference to verify the authentication.

VII. Automation in Processing

Smart contracts give a power to the blockchain based supply chain to automize many processes. Once the conditions are met in the code of the smart contract, it will execute the agreed conditions automatically. The major benefit of a smart contract is non requirement of a central authority to ensure contract terms like banks or courts. (Accenture, 2018) has also discussed the idea of using smart contract enabled blockchain in supply chain and logistics.

Automated transactions are naturally faster, cost effective and error proof as compared to humans. Due to autonomous process in the blockchain based supply chain, better utilization

of resources is possible. Automatic transfer of funds is also a feature of the blockchain based supply chain, which is fast and reduces the risk of shortage of financial resources.

VIII. Operation of IoT in Supply Chain

The blockchain based supply chain uses sensors and IoT to identify the product and its status in real time, which generates a lot of data, that needs to be stored accordingly with time. Blockchain can solve this problem by recording status and sharing it to the required members (Petersen, 2017). Operation of IoT in supply chain can work better with blockchain technology. As it is the foundation of “Supply chain 4.0” and without this, the idea of “Industry 4.0” is not feasible and it also has an impact on the supply risk. In traditional supply chain, batch production is unavoidable, and batches of certain quantity are required to operate economically. But with “Industry 4.0”, batch size can be reduced to one piece (Witte, 2017).

Because of making small batch size, economical supply risks can be mitigated. This will make supply chain more agile, and adaptation of new product design will be very fast. Products can meet the trend and reduce the untrendy product supply in market.

IX. Catching Counterfeit Products

In compliance, it is necessary to identify and remove the counterfeit product. These products can adversely affect the consumer and can have a destructive impact on reputation of a company.

In a medical supply chain, production of counterfeit medicines is increasing in the third world countries. Pharmacies are liable to ensure originality of the drugs which they sell that is why they must make their network secure against entering any fraudulent or expired drugs. The blockchain based supply chain can ensure to catch counterfeit products at the very beginning, making it difficult for counterfeit products to enter the supply chain.

X. Temperature Monitoring

The blockchain based supply chain uses smart devices i.e., smart containers, smart carriers etc in its network. These devices record environmental conditions inside and outside of the container or carrier. The environmental data can be useful for taking many environmental related decisions and regulatory complaints i.e., CO_2 emissions. Monitoring of environment within a container records temperature, humidity and stores it on the blockchain with time and variation in reading. This stored data can then be used later as verification of the environmental conditions, agreed with any logistic company.

The control of environment in the blockchain based supply chain provides strength to the supply chain to deliver the products at desired temperature, because the change in temperature for frozen products results in wastage of goods. Typically, the food and animal transportation are temperature sensitive modes of transport in a supply chain. When the product is wasted during transportation, this will lead to shortage of goods at required place, which can adversely affect the business.

With the blockchain based supply chain, the change in temperature can be timely detected and actions can be taken to reduce the risk. Timely actions can be taken to improve the temperature conditions before the products are wasted because of temperature abuse.

The products which are already wasted during the transportation are timely deducted, and there is no need to transport the wasted products to the destination, this will save the transport costs and on the other hand alternative products can be arranged.

XI. Dispute Resolution

Blockchain based supply chain records every transaction that provides a strong and reliable reference sorting disputes in supply chain. Many stakeholders are involved in a collaborative supply chain where a lot of communication is needed, which some time may generate dispute. The dispute may be due to violation of terms, bad service in terms of lost goods or damaged goods which would result in claims. Stakeholders must investigate the reasons of the loss.

For example, a food container is shipped from point A to B, and on arrival of the container at point B the food is rotten. It will be hard to investigate at which point during transportation temperature was raised.

The blockchain based supply chain records temperature during complete journey of container and the data is shared to every party involved, which makes easy to find the responsible party for the damage.

4.14 Possible Limitations of the Proposed Solution

Although there are many possible benefits of the proposed solution; but there are some limitations associated with it, which are described below.

a. Implementation Limitation:

The proposed concept does not fit to all kind of supply chains; it is only suitable and is limited to the FMCG supply chains where road-sea-road transport is used.

b. Bringing all the Supply Chain Stakeholders on the Same Page:

The main challenge of the proposed concept is to bring all the stakeholders of the FMCG supply chain on one page, as the supply chain involves collaboration of many stakeholders and all these stakeholders might use their own processes, software, and tools, so it will be difficult to convince all of them to use the same concept.

c. Implementation Costs:

Another major issue with the proposed concept is the implementation costs, even if all the stakeholders agree to use the concept. Although I am confident that the benefits of this concept would be more than the efforts, still it is a big challenge to inject funds into developing this concept.

d. Change Management:

Another major issue with this concept is the change management. Nobody likes to change a running system, but if some stakeholders of the supply chain agree, still it would be a difficult task to drive the change management process in a collaborative network.

4.15 Chapter Conclusion

Blockchain is a decentralized ledger of records and ownership of an asset that can record and monitor any type of transaction distributed across the entire network.

Transactions are stored in form of cryptographical blocks, and these blocks are arranged in a sequence of their generation, normally alteration in the blocks are impossible making it secure.

Although blockchain was developed to introduce the digital currency, but blockchain technology possess key features, which can be used to solve many problems in financial and non-financial sectors of the business. The use of blockchain is not completely matured yet in the business sector as it is still in its developmental phase. Some supply chain companies are using blockchain on trial basis in their supply chain; the prime focus of blockchain is on visibility, transparency, and paper trail within the supply chain.

Supply chains of today are more vulnerable than in the past due to the growing globalisation, many companies manufacture and source internationally, which leads to different risks in the supply chain, these risks need to be identified and mitigated properly.

Blockchain technology can be used as a risk mitigation tool by integrating its basic features, like data storage and retrieval, automation of supply chain processes would mitigate risks and improve performance of supply chain.

With the implementation of blockchain in a supply chain, the overall performance of supply chain can be improved i.e., visibility, traceability, demand forecasting, access of information etc. which will reduce the risks associated.

Chapter 5: Automation of Operational Procurement

In this chapter, the automation of operational procurement is discussed to mitigate the risks associated with it, further a comparison between the conventional operational procurement process and the proposed automated concept is explained. All the processes involved in the respective comparison are deeply investigated, keeping their pros and cons in mind, and the concepts have been identified, how these risks can be reduced.

5.1 Operational Procurement

Operational procurement commonly known as P2P (procure to pay) or R2P (requisition to pay) is the process of requisitioning, purchasing, receiving, paying for the good or services needed by an organisation. The names P2P / R2P come from the ordered sequence of procurement and the financial processes, starting with the first step of procuring goods or services to the final step of paying for it (Rouse, 2012). Operational procurement deals with the orders only after a contract has been negotiated and agreed, and it works for the daily purchasing needs of an organization. It involves buying goods and services for an organization, managing deliveries and contract, and finally dealing with complaints if any (Lin, 2017). A typical procure to pay process is shown in below figure 5.1

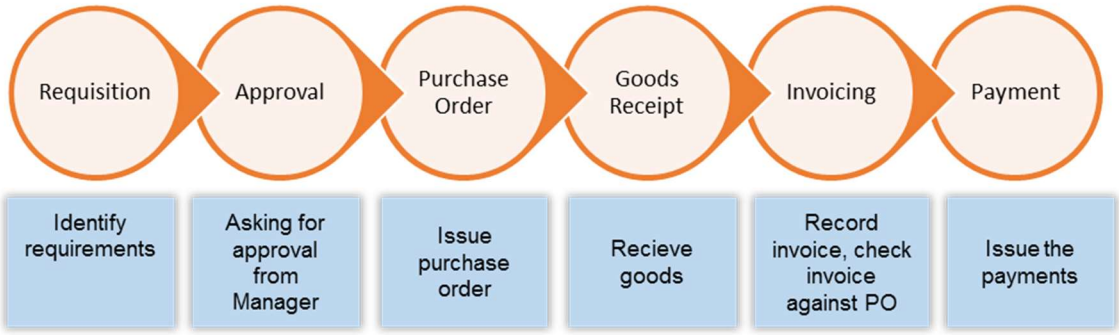


Figure 5.1. Conventional "procure to pay" (P2P/R2P) process: figure based on (procuredesk, 2019) *&* (amc, 2017) *with modifications*

A typical traditional operational process involves many manual tasks, it also includes many repetitive and small tasks i.e., identifying requirements, management approvals, issuance of purchase orders, payments etc. In addition to above, a proper follow up and communication with suppliers is required (Claritum, 2018). The manual operational procurement process also consists of manual documentation processes, which requires a lot of space for document storage that could be prone to damage, loss, and theft (Bowers, 2017).

In the current digital era, most of the businesses are still using the conventional P2P process to meet their operational procurement needs, knowing the fact that the digital revolution is eliminating the conventional procurement methods. This ignorance of using the conventional P2P process is one of the most prominent risks associated with operational procurement.

Indeed, it is hard to understand that still the P2P automation to mitigate its risks by significant improvements with speed and accuracy is still under discussion for so long (Leonard, 2013). SAP conducted a survey in a partnership with the University of Applied Sciences Würzburg-

Schweinfurt Germany with more than 450 procurement leaders as participants across the globe. The survey showed, more than 83% of procurement leaders are of the opinion that the digital revolution would influence the supply chains in many negative ways, because most of the companies are not ready to embrace the digital change yet. While on the other hand, there were only 5% companies, which are already in the process of adopting to the digital revolution and have already implemented highly automated processes in their organizations (Vollmer, 2018).

5.2 Risks with Manual Operational Procurement

The conventional operational procurement includes many manual tasks to performance a P2P cycle. Every node of the P2P process is prone to different risks. The P2P process includes many individual processes that involves many people and is carried out across different parts of organization. If P2P process is executed manually, it can lead to complexity, could take more time & effort, and allow room for human errors (Taylor, 2018). Some prominent risks associated with manual & conventional P2P processes are shown in Figure 5.2. and are explained below.

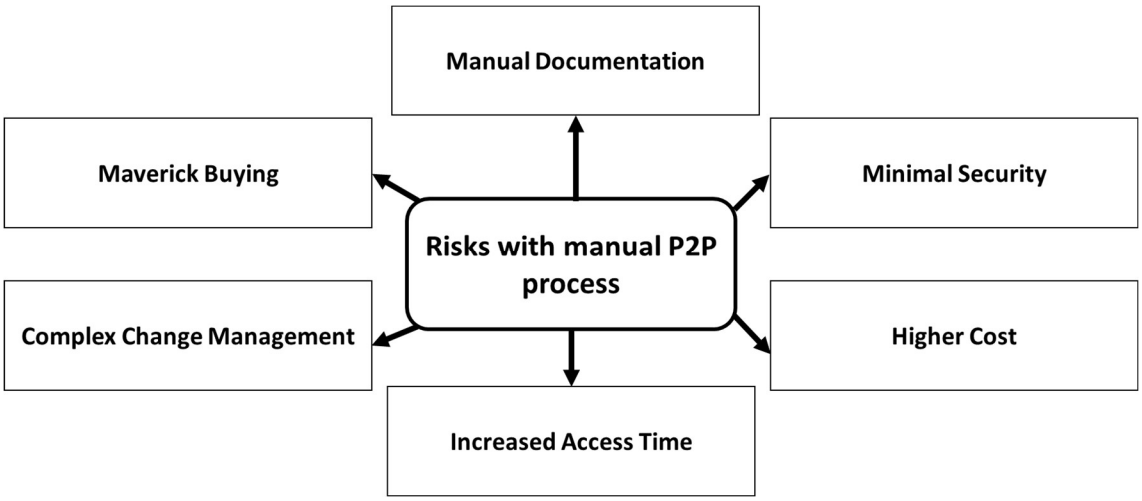


Figure 5.2 risks with manual "procure to pay" (P2P/R2P) process (own content)

I. Manual Documentation

Manual documentation is one of the biggest risks associated with manual operational procurement. It means that the employees perform all the processes manually. This process is slow in terms of performing tasks, it includes a risk of damage to sensitive and important records in case of fire or natural disaster, the documents can be misplaced, requires a lot of records storage space, hard change management in terms of adding or deleting new information to the purchase, increased access time, low security in terms of theft, and higher costs.

II. Maverick Buying

It is the risk that an employee buys product without the consultation of the procurement department. Maverick Buying refers to a procurement, which is uncontrolled and unplanned

and is executed without the consultation of procurement department; the process does not comply with the standard purchase practices, framework agreements, price comparison and negotiation (Nannore, 2014). It has always been a top priority for businesses to eliminate this risk, but still it exists. Maverick Buying causes spend “leakage”, it impacts the spend transparency due to the usage of non-contracted standard suppliers (Rogers, 2021). Maverick Buying has adverse effects on any organization and can push a company closer to the brink of insolvency. Maverick Buying costs time, money, and manpower to perform the purchasing tasks and if the organizations do not have total spend visibility, they cannot perform effective spend analysis. Organizational money is wasted, proper data management is compromised and above all the risk of non-compliance increases (Biedron, 2018).

III. Risk of Damage and Misplace (Minimal Security)

This type of risk is associated to the documentation part of the process and means that the documents can be misplaced and can be prone to damage. The manual P2P process is always prone to security risks because the manual documentation can be less secure than electronic documentation systems.

IV. Complex Change Management

In any process, change management is always a difficult task to perform and in the manual operational procurement, changes are difficult to manage. The orders, documents and requests are not always complete and require changes with time and demand. A change to an existing order could be laborious and time consuming.

V. Increased Access Time

Short access time to any process is always the goal of any business manager, everyone wants to get things faster but being fast is not always the correct way to perform tasks, rather the target would be a faster as well as effective process. In manual procurement process, the access time to store, organize, search, and find an order or its related files are highly time consuming and painful, it slows down the overall process due to which the organizational targets are not achieved.

VI. Higher Cost

Manual processes are always expensive as compared to the electronic processes because manual processes include many human resources, which contribute to overall cost. In addition to labour work, manual accessories are not reusable, making it hazardous for the environment. Electronic processes are environment friendly.

5.3 Automated Operational Procurement Processes

The idea is to automate all the above steps of the P2P process, which could save a lot of time, effort, and costs. The P2P process steps are broken down into blocks for automation with the help of a software running in the back end. Figure 5.3 shows how an automated P2P process should look like when it is divided into 4 blocks.

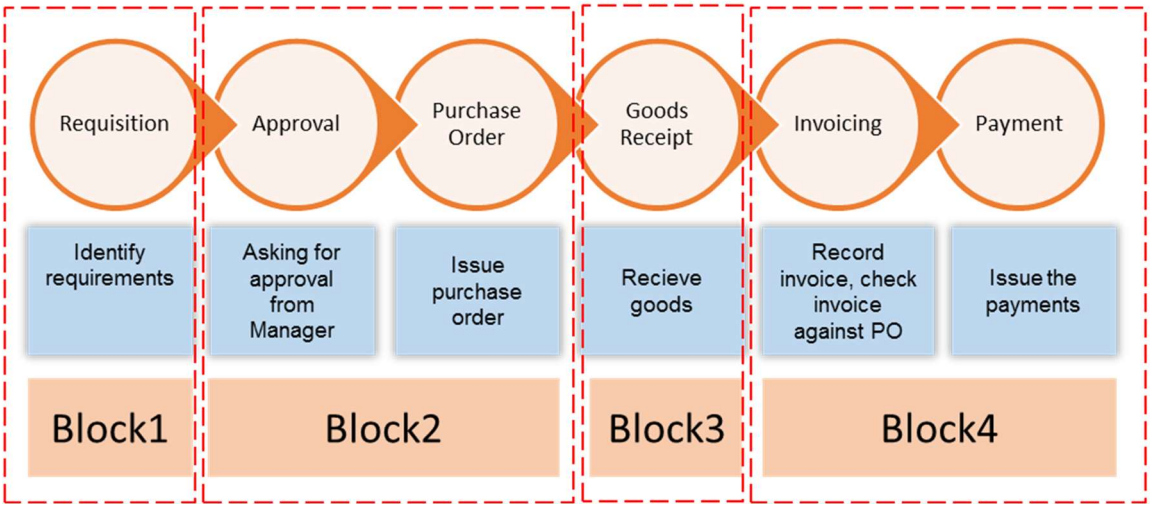


Figure 5.3 Automated "procure to pay" (P2P/R2P) process split in blocks (own content)

The automation of the process steps will result in great cost savings and mitigate the major risks associated with P2P process.

5.4 Conventional Operational Procurement Process Execution Cycle

The end-users identify their requirements and send the information to the operational procurement department to purchase their desired products. The operational procurement department receives the request and performs two tasks.

Task 1

As a first task, the P2P department takes approval from the respective manager if required.

Task 2

After approval from the manager, the P2P department contacts the suppliers and issues a purchase order (PO) to the supplier for the desired products.

After the contact with the P2P department, the suppliers receive the POs on their end and perform two sub-tasks.

Sub-Task 1

The suppliers check whether they have the requested products in stock, if the products are not available, it contacts its internal departments to arrange the product and if the product is available it proceeds to sub-task 2.

Sub-Task 2

The supplier contacts its logistics department and arranges the dispatch of the requested product to the customer along with a hard copy invoice. The requested product is shipped to the customer.

The warehouse on the customer side receives the products and informs the procurement department about the receipt of the products. The operational procurement checks the quantity

and quality of products against the PO's, and in case of discrepancy, it informs the internal claims department and suppliers. In case of no discrepancy, the P2P department sends information to the end user about the arrival of the product and informs the finance department about the payment approval. The finance department issues the payments to the supplier and it concludes the P2P execution cycle. The conventional P2P process cycle is executed as shown in figure 5.4a and figure 5.4b.

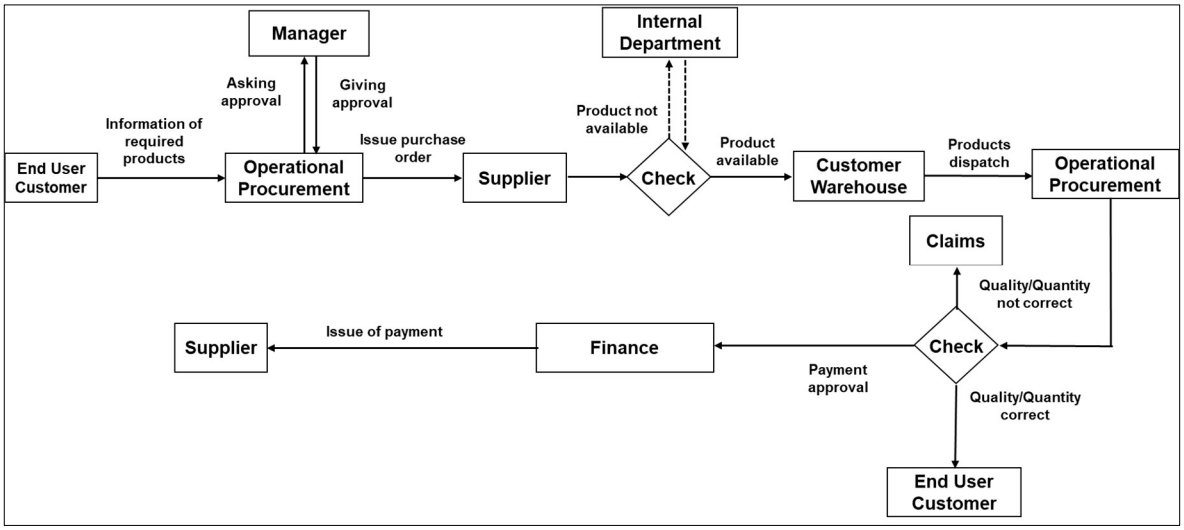


Figure. 5.4a Conventional P2P process execution cycle (own content)

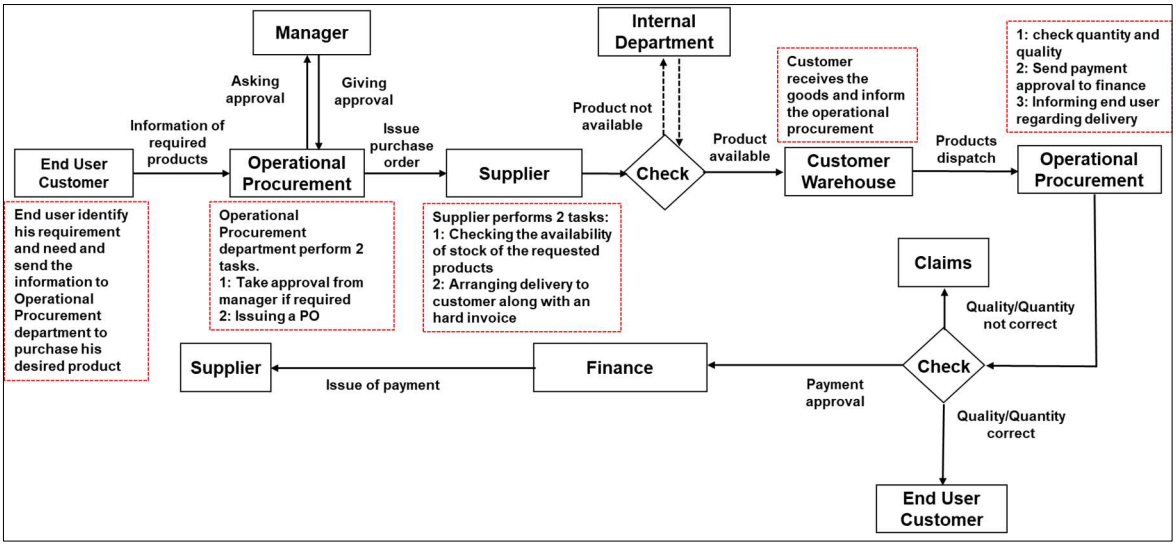


Figure. 5.4b Conventional P2P process execution cycle with step explanation (own content)

The conventional P2P process works satisfactory, but it requires a lot of time and effort. It engages the procurement department in many unnecessary steps and increases their efforts, while on the other hand the procurement department does not have enough time to focus on strategic topics. In order to make the process faster and effective, an automated concept is

proposed which will reduce approx. 40% of the process steps, further; it will increase the efficiency of the process.

5.5 Proposed Automated Operational Procurement Process Execution Cycle

In the proposed concept, the P2P process is mainly automated, the exchange of documents across all nodes is electronically executed; the invoices generated are automated, and the payments are paid electronically. An automated P2P process execution cycle is shown in figure 5.5a and figure 5.5b. It is evident from the figure 5.5a and 5.5b, that the P2P process steps have been reduced with the automated concept.

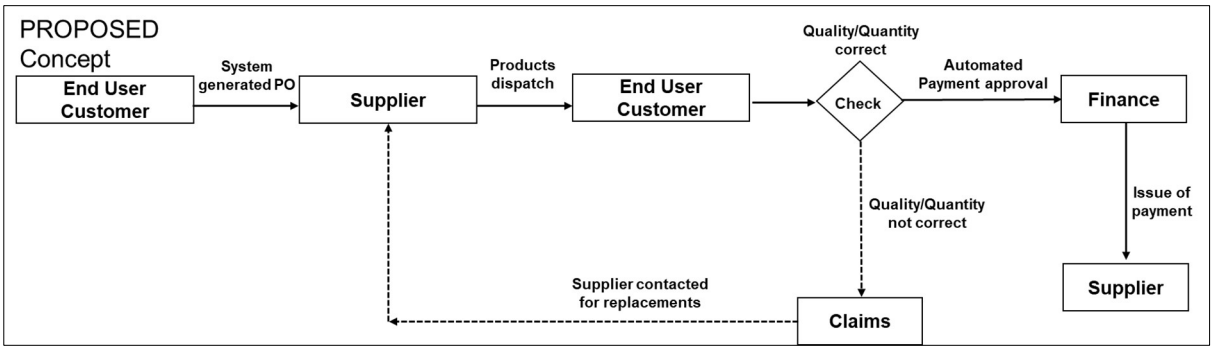


Figure. 5.5a Automated P2P process execution cycle (own content)

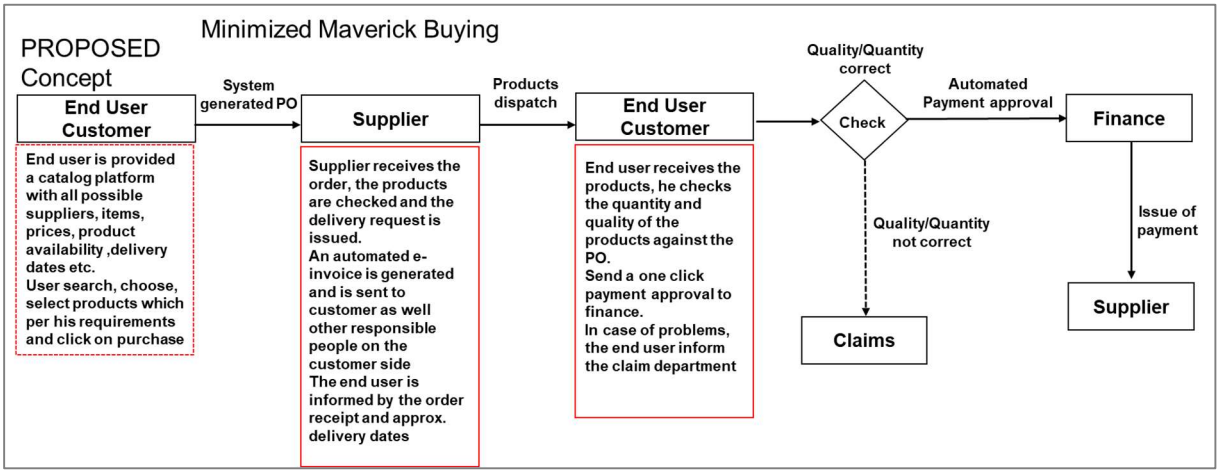


Figure. 5.5b Proposed automated P2P process execution cycle with step explanation (own content)

The end-users should be given an access to an automated user-friendly system that is running behind the scene. The users will login into the system and access a catalogue that consists of all the possible supplies /products they need. The end users will search for the products they need, as a result they receive a complete catalogue of all the supplies/products along with the information of suppliers who are providing these products, price comparisons, availability information, delivery dates and much more. With electronic catalogues, the suppliers offer and

provide products electronically and also provide buyers more visibility into product and price information (Matters, 2017).

The catalogue provides the end users an opportunity to choose which product and supplier fits their requirements at the best. The end users finalize their choices and order them through the online platform. In the background within milliseconds, all the parameters are checked for which the users already have pre-approvals, and the PO is sent to the supplier.

As the suppliers will also be using automated systems on their end, their system checks all the information, item location, availability etc. of the products and this information is sent to the automated dispatch desk. The goods/items are dispatched to the end users and a computer-generated invoice is also sent to the end users as well as to their finance department.

The end users receive the products. The quantity and quality of the products are checked against the PO using bar code scanners, if the orders are complete according to the requirements, an automated message is sent to the finance department and the finance department processes the payment accordingly.

The automated proposed process will save a lot of time, effort, and resources. It will also contribute to the overall transparency of the procured goods and reduce the associated risks.

5.6 Benefits of Proposed Automated Operational Procurement Process Execution Cycle

P2P automation is the need of time. The companies which do not automate their processes will have to bear drastic consequences and will stay far behind and there are chances that they even run out of business (Grassl, 2015).

Some key benefits of P2P automation are shown in Figure 5.6. and have been explained in detail.

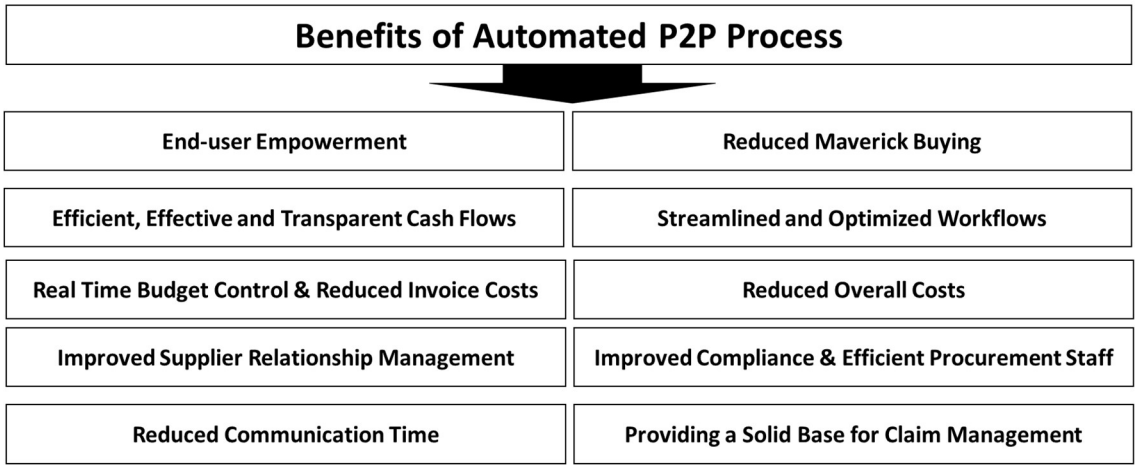


Figure. 5.6. Benefits of automated P2P process execution cycle (own content)

I. End-user Empowerment

The main and important benefit would be the empowerment of the end user to skip P2P department for the basic supplies. The end users will be provided with electronic catalogues,

where they could select their required products easily. They will not consult the procurement department repeatedly and will have the freedom to buy products according to their needs from the approved available options. With the automated solution, the end users will bypass the long waiting time which they spend with their operational procurement department.

II. Reduced Maverick Buying

Maverick Buying means that when an employee within an organization procures a product or service from different suppliers without involving the procurement department. This is one of the biggest threats to any procurement organization, because Maverick Buying simply bypasses the procurement processes and procedures, contracts, negotiations, price comparisons, and contract agreements etc. (Linda, 2019).

By automation of the P2P, the transparency level of spend increases by providing the clarity who is buying what? from whom? at what price? thus the Maverick Buying could be significantly reduced. There are certain other ways to stop the Maverick Buying; some organizations prohibit Maverick Buying as a company policy, some establish clear processes, some arrange trainings to educate the offenders, but all these are useless without automation, if you want to achieve better results, you need to automate all the processes (Charles, 2013). Nevertheless, the automation of the P2P process is the one of the solutions to get rid of Maverick Buying.

III. Efficient, Effective and Transparent Cash Flows

It is always the goal of an organization to implement efficient, effective, and transparent cash flows in the business, but it is difficult to achieve these targets with the manual processes. Manual processes cannot be efficient as well as effective, however with automated P2P process, effective and efficient results can be achieved.

Further, the overall cash flows will be more transparent. P2P automation software can provide better cash management capabilities and impressive earnings growth despite the challenging market conditions.

IV. Streamlined and Optimized Workflows

By automating the P2P process, the workflows will be optimized and streamlined. This enables the procurement to immediately recognize the approved suppliers, product prices, and agreed terms & conditions. The automated process will also enable all stakeholders, including suppliers, to see the orders in real time (Freer, 2017). On the other hand, this will bring clarity and transparency among the processes, which would result in better cooperation, collaboration, and integration among different departments.

V. Real Time Budget Control & Reduced Invoice Costs

Real time budget control can give us the opportunity to keep a track on our organizational funds. The automation of the process has made it possible for an electronic invoicing to go directly to payment without the involvement of any human, as a result it reduces the invoice costs immensely (Palettesoftware, 2016). From a practical experience, an average invoice cost in manual system can range from 8€ to 12€, whereas an automated solution could reduce the costs up to 70%.

VI. Reduced Communication Time

The communication time between suppliers and buyers is always crucial; the automation of P2P will reduce the communication time between the buyer and supplier immensely. According to a research, typical phone calls between a buyer and a supplier can take an average of six minutes per call for basic interactions (Claritum, 2018).

Further, the buyers also need time to communicate with their managers for approvals, and other people involved in the process that also requires time. By using the automated concept these steps will be removed from the process, it will automatically reduce the communication time.

VII. Reduced Overall Costs

The automation of P2P has a direct impact on the cost savings, enabling automated P2P processes save in millions by reducing Maverick Buying, reduced manual changes, reduced reworks, reduced cash discount losses (myInvenio, 2019).

VIII. Improved Supplier Relationship Management

Supplier relationship management (SRM) is considered as part of the strategic procurement, but by the automation of the P2P process, the SRM will also be significantly improved. In short, the automation of the P2P process will provide base for the strategic procurement department to work on their supplier relationship management policies.

IX. Improved Compliance & Efficient Procurement Staff

The automation of the P2P process results in transparency of overall spend of the organization; automatically it will reduce the chances of fraud and will improve compliance. Another vital benefit of the P2P automation is the increase in the efficiency of the procurement staff. The automation saves a lot of time; this will make the procurement staff to act more efficient and productive.

X. Providing a Solid Base for Claim Management

Another important benefit of the P2P automation is that it provides a solid base for a better claim management process. The automation of claim management process embedded with the automated P2P process along with its potential benefits has been discussed in detail in chapter 8.

5.7 Limitations of the Proposed Solution

The proposed model can help to achieve the above benefits, but I also foresee some limitations of the proposed model, which are mentioned below.

a. Reduced Headcount:

Automation of the P2P process would be beneficial for an organization, but as a downside, it could contribute to reduced headcount. This downside applies to other implementation concepts in this research.

b. Implementation Costs:

Another downside of the proposed concept is the implementation costs for an organization, the change of process from manual to automated would need a good amount of implementation costs. Large size companies with a large number of operational activities might find it beneficial to automate its P2P processes but small and medium size companies would rather use the manual processes to save the implementation costs.

c. Lack of Employees Knowledge:

The automation of the P2P process would be a door opener for an organization to train its employees to achieve maximum benefits, but if the employees use the automated process without proper knowledge, that will lead to extra losses.

d. Risk of Private Orders Execution:

Another major issue with the proposed solution is, the possibility of employees to order privately without been traced. As the process works on pre-approvals from managers, which could provide an opportunity to an employee to order something for himself/herself privately which could not be controlled immediately and this a major drawback in the proposed solution.

e. Bugs in the System:

In any automated solution with lesser human interaction, there is always a danger of bugs in the system, which could disturb the whole system. In this case wrong orders with wrong quantities could go to wrong suppliers or to wrong customers, which could result in extra costs. When bugs are detected on time, it would not have an impact on the organization, but if not, it could be expensive for the business.

5.8 Chapter Conclusion

P2P is the operational part of procurement and it revolves around the execution of the day-to-day procurement activities. It could be referred to as the implementation playground for the achievements of strategic procurement in terms of negotiation and securing best prices.

If the operational procurement is not on the right track, the overall procurement will be affected. P2P automation is the need of time and the companies that do not automate their procurement processes will run out of the business.

The automation of the P2P process has a direct impact to improve the processes in the other types of procurement. The automation of P2P processes will not only reduce the overall business costs, but also the people working in the P2P departments will focus on more strategic topics which will bring more value to the organization. All the process steps of P2P should be automated and treated as one process backed by a user-friendly software.

The automation of the P2P will also increases the transparency level of spend. The cash flow management will become more effective and efficient, and the workflows will be streamlined. It will also empower the end users to procure by themselves against the agreed terms and prices achieved by the strategic procurement department.

Chapter 6: Automation of Tactical Procurement

In this chapter, it is shown how automation can help to mitigate the risks associated with tactical procurement, further this research deep-dives in the tactical procurement processes and analyses, what are the prominent risks associated with tactical procurement? How huge the impact of these risks could be to any organization?

Later, a comparison between the conventional / manual processes of tactical procurement with the proposed automated tactical procurement has been explained. All the processes involved in tactical procurement are further investigated, keeping in mind their pros and cons. Further concepts have been identified how these risks can be reduced or mitigated.

6.1 Risks with Tactical Procurement Processes

The conventional tactical procurement includes a lot of different processes which are dependent on each other. On one hand, all these steps are connected to each other in such a way, if one of them does not perform properly, it will have a negative impact on the entire tactical procurement.

On the other hand, all these processes are standalone within themselves, and different risks are associated with each process. If these processes are manually executed, they would lead to complexity and would take more time and effort to be executed, it will also make it susceptible to human errors (Taylor, 2018).

Below are some prominent risks associated with manual & conventional tactical procurement (S2C) processes.

I. Manual File Storing Process

This is one of the prominent risks associated with the conventional non-automated procurement processes, which means that all the file storing processes are performed manually by the staff. The manual processes are slow in terms of tasks performance, they include:

- Risk of damage to sensitive and important records in case of fire or any natural disaster.
- Requires large storage space
- Hard change management in terms of adding or deleting new information to your purchase
- Increased access time
- Low security in terms of theft
- Higher overall file management costs
- It can also lead to losing your supplier and clients, who would not want their information to be mishandled

Below are some major issues associated with manual processes in procurement.

a. **Uncontrolled Purchasing:** It is the risk, where a buyer buys products without the consultation of the procurement department from wrong suppliers.
b. **Risk of Damage and Misplace:** This risk is associated to the documentation part of the process; the documents can be easily misplaced and are prone to damage.

c. **Difficult Change Management:** Not all the orders are perfect every time, most of the time, it is needed to change the orders because the customer requirement is changed, which makes it difficult to track all the changes.
d. **Long Access Time:** As the process is manual which automatically implies that the access time to store, organize or hunting an order would be highly time consuming, and would result in slowing down the overall process.
e. **Lack of Security:** The manual S2C process is always prone to security risks; they can be less secure than electronic file storage systems. Misplaced documents can easily land in wrong hands.
f. **Higher Cost:** Manual processes are always expensive in comparison to the electronic processes.

Besides the above general manual process risks, there are some typical risks associated with tactical procurement processes, which are:

II. Requirements Specifications Risks

These are the potential losses due to a project's requirement gathering process, such risks are directly tied to the quality of requirements in which low-quality requirement leads to the risk of failing the entire project (Spacey, 2017).

The risk is, not to have the correct requirement specifications from different parties involved in the procurement process. Due to involvement of different parties within procurement, if a customer/organization wants to procure products or services and they are not communicated to the procurement department properly and clearly, the whole process would be started with incorrect & insufficient information. It will result in "garbage-in garbage-out" scenario.

The requirement specification risks could be wrong stakeholders, missing stakeholders, incomplete or ambiguous requirements, infeasible or conflicting requirements.

III. Tender Process Risks

In procurement, tendering means to invite bids for a specific procurement project within a definite deadline (Kenton, 2019). The formal request for a tender is called a request for tender (RFT). The target of tendering process is to invite the right parties to the right tender in order to ensure maximum competition and transparency.

The tendering process has a direct impact on other processes of tactical procurement, if the wrong suppliers are invited to participate in the tender, there are great chances to get wrong suppliers and wrong prices on board.

In the manual tendering process, there could be situations where many deserving parties/suppliers are not invited to the tender, this results in wrong or incompetent suppliers, lack of transparency, and little room for negotiation, which leads to extra costs and less accountability.

IV. Negotiation Risks

The negotiation process is one of the most important steps in the tactical procurement process, the process starts after the suppliers submit their offers. The suppliers which are shortlisted against certain criteria are invited for negotiations. This is the deciding point to make sure that

the right suppliers, with the right prices, right service level agreements (SLAs), and terms & conditions are through to the next rounds.

Normally the process takes some time to finalize the final supplier, the suppliers are invited to different rounds to make sure to have the right supplier on board. The traditional negotiation processes are face-to-face. These processes are so effective that one does not want to automate them.

The risk though, is the waste of time because the procurement department is involved since the beginning and some of the suppliers are rejected in the 2nd or 3rd round of negotiation where the suppliers do not comply with SLA's, terms, and conditions etc.

The automation can help to save time and effort by further filtering the real deserving suppliers to sit in face-to-face negotiations. The proposed concept is to send the SLA's and terms & conditions in advance to the suppliers with pre-defined criteria, the suppliers should submit their response electronically. These responses are checked and executed against an algorithm to satisfy those criteria and the suppliers are shortlisted for the next round. Only the suppliers that comply to those criteria, are invited for face -to-face negotiations.

Another important factor is to send the right negotiators to the face-to-face negotiations with the shortlisted suppliers; a wrong negotiator can ruin the process and the benefits could go to the suppliers. The negotiators should be skilled enough to ensure your company gets the maximum out of the deal and should have the capacity to understand the breaking points of the suppliers.

V. Contract Management Risks

Contract management is a critical part of the tactical procurement. In this process everything is documented that is agreed between two parties and has a legal status. In every business, contracts are important because they document the expectations, prices, terms, and conditions agreed by the parties involved and they safeguard all the parties in case of mishaps (Faris, 2019).

In manual contracts system, the contracts are signed and stored in the documented hard form. There are risks that contracts may get expired and are not noticed by the parties which could result in damages. Other risks associated with manual contracts could be possible human errors, rough discounts, waste of time (Carrera, 2018). According to research by an independent international Association for contract & commercial Management (ISCMM), a poor contract management costs companies 9% of their revenue (Cummins, 2012).

VI. Supplier Data Management Risks

In tactical procurement supplier data management is also referred to as supplier master data management. It is the framework which is used to manage a detailed set of records about the suppliers working with companies. This information includes goods & services i.e., source of suppliers in full details (smart, 2019). Supplier master data is the key for a long lasting effective strategic administration of your suppliers, supplier management is often a complex task where a lot of documentation would be involved and needs to be efficiently managed (Duteil, 2017).

Information is power in any industry. The information is directly proportional to the number of suppliers in any business. As the number of suppliers increases, it also increases the

information related to the suppliers, which results in complexity and making it prone to risks. Despite the clear benefits of having high quality of supplier master data, many companies still rely on their manual processes to manage complex data (Commerce, 2017).

VII. Supplier Evaluation Risks

Supplier evaluation is the base for supplier selection process. The supplier selection is based on the ability of a supplier to deliver their services in terms of quality, quantity, cost, and delivery time (Employment, 2011). An automated supplier evaluation process is presented in chapter 8.

6.2 Tactical Procurement Automation Concept

Tactical Procurement, also known as “Source to Contract” S2C is the process of procurement which starts from the requirement identification and ends with a complete contract with suppliers. The steps involved in this process are deeply dependent on each other and if one of the process steps is executed improperly, it will have a negative impact on the overall strategy. A typical tactical procurement process is shown in figure 6.1.

Figure 6.1 Typical tactical procurement process: figure based on (amc, 2017) *&* (Procurement, 2012) *with modification*

A typical traditional tactical procurement process includes a lot of manual tasks and events, it also includes many repetitive and small tasks and above all a proper communication must be done at any given time with the suppliers (Claritum, 2018).

This manual procurement process also includes many manual document filing processes which itself requires a lot of space for document filing that could be prone to damage, loss, theft (Bowers, 2017). In this digital era most of the companies are still using the conventional S2C processes despite knowing the fact that the digital revolution is eradicating the conventional procurement methods (Leonard, 2013).

According to a survey from SAP, most of the procurement leaders are of the opinion that the digital transformation would affect the supply chains because many of the companies are still not ready to change, on the other hand there are very small number of companies which are already in the process to digitize their procurement processes (Vollmer, 2018).

The concept discussed in this chapter is to automate the tactical procurement process to save a lot of efforts and time, and it will also generate more savings and will bring a high level of transparency. Furthermore, few processes cannot be fully automated because there are emotions and human interactions involved, but if the other related processes are automated it will provide a greater visibility and transparency to companies and they will get huge benefit from it.

In the proposed solution, the processes of tactical procurement have been broken down into blocks and automation concepts are discussed. The automated processes will result in great cost savings and will contribute to mitigate the major risks associated with S2C processes. In

this section the conventional/manual S2C processes have been compared with the proposed automated solutions and the potential benefits which could be achieved, have been identified.

6.3 Conventional Tactical Procurement Execution Cycle

This process starts when companies want to develop a short-term strategy to keep the business run smoothly. The companies identify their needs and then start to collect information regarding their requirements. Requirement specification is the first step of the tactical procurement; and is the process of collecting and writing down the requirements of a stakeholder. The goal of this process is to get complete, consistent, clear, and easy to understand requirements (Elgabry, 2016). In the conventional tactical procurement, the tender process must go through different steps and there are very limited parallel steps involved. First a team is planned, tender and evaluation criteria are defined, supplier long list is created and then tenders are issued and published.

The manual process can work on satisfactory level and can contribute to the company's goals, but it requires a lot of time, and it engages the procurement department in so many unnecessary steps and increases their efforts. While on the other hand the procurement department does not has enough time to think on strategic topics. In order to make the process faster and effective, automated concept is proposed which will save a lot of time and effort and will increase the overall savings of the company.

6.4 Proposed Automated Tactical Procurement Execution Cycle

In the proposed concept, all the processes associated with S2C are automated. Furthermore, the exchange of documents and communication across all nodes are electronic. The requirement collection, the tender process, the negotiation process, the contract management process, and the supplier management process are automated with the help of software solutions running in the background. An automated S2C process execution cycle is shown in figure below 6.2. and the concept of each process step is mentioned in detail.

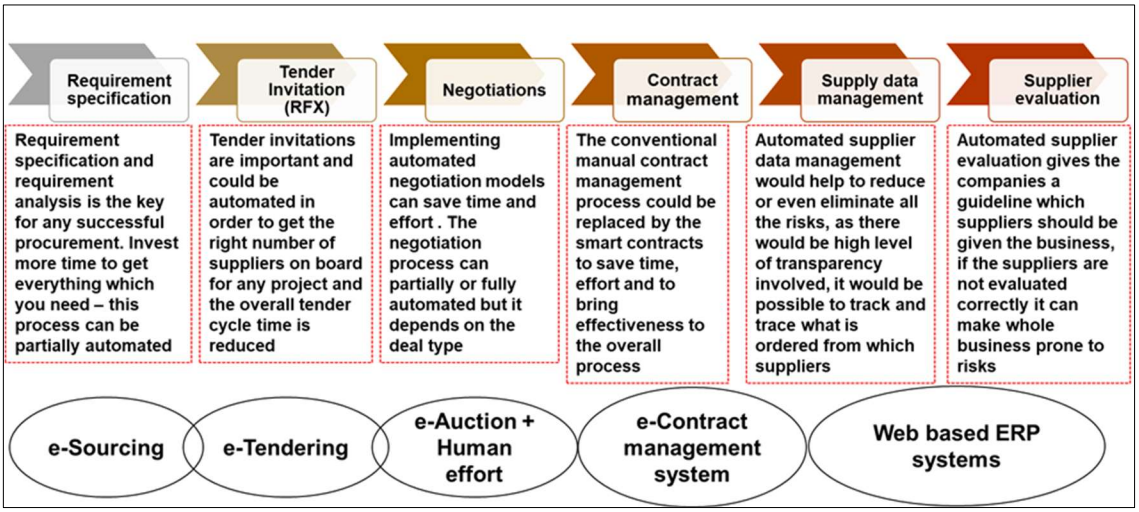


Figure 6.2 Proposed automated tactical procurement process (own content)

6.4.1 Automated Requirement Specifications

The requirement specification process cannot be fully automated as human interaction is vital. However, it is proposed to implement a platform between the customer and procurement.

The procurement would collect the requirements through that platform accompanied by standard templates. Once the requirements are collected, an automated requirement analysis platform will fine-tune the information and perform automated analysis of the requirement specification. It will provide a firm basis to the next steps of the S2C process and will also reduce the "garbage-in garbage-out" risk.

Figure 6.2a Requirement specification in tactical procurement process (own content)

6.4.2 Automated Tender Processes

With the automation of tendering process, the overall tender cycle time is reduced. The automated process is designed to filter the deserving suppliers out of long list of suppliers. The suppliers are provided with the platform where they can participate in the pre-defined tender templates. The automated tender system analyses all the participants and generates a short list of suppliers. It helps in fast and accurate pre-qualification of suppliers. The automated tendering process can also be called as e-tendering process.

Figure 6.2b Tender process in tactical procurement process (own content)

6.4.3 Automated Negotiations

Implementing automated negotiation models can also save a lot of time and effort. The negotiation does not mean achieving only the best price, in fact it could be achieving best SLAs, better delivery times, and better conditions etc. The negotiation process can be either fully or partially automated depending on the deal type. In the automated negotiation, different models which could be referred to as e-auctions are used. Some of the famous auction models are: English Reverse Auction, Sealed Bid Auction, Dutch Forward Auctions, Japanese Reverse Auctions.

Figure 6.2c Negotiation process in tactical procurement process (own content)

6.4.4 Contract Automation

The idea is to replace the manual contract management systems with automated contract systems, because with the passage of time these manual trends will be outdated. These could be referred to as smart contracts. A lot of time can be saved in the signature process. There are many software(s) already in the market where all the contracts are digitally signed. The automated contracts are efficient, there is no need to spend time on building templates. With automated contract management system, it is easy to trace and track the status of the contracts, automated reminders for the deadlines and renewals. It will lower the overall cost, make the process more transparent, and will also provide better security and stronger compliance (Naughter, 2017).

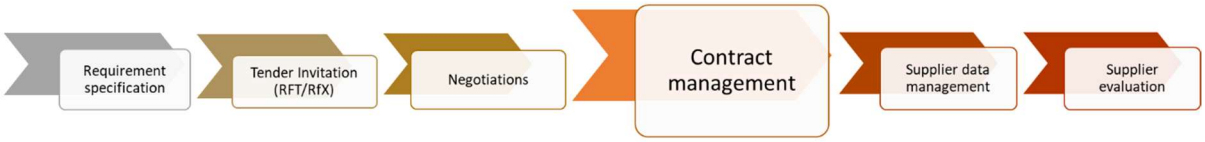


Figure 6.2d Contract management process in tactical procurement process (own content)

6.4.5 Automated Supplier Data Management

Automated supplier data management would help to reduce or even eliminate all the risks, as there would be high level of transparency involved. It would be possible to track and trace what is ordered from which suppliers, how much, why, and where. It has a direct impact on spend management process. It will also help to minimize the risk of fraud and improve the claim management process. The automation of the process provides the opportunity to the companies to utilize their time more effectively and focus on finding the right suppliers for their needs. It also tracks the active suppliers and reduces the time spent on managing the non-active suppliers; it makes the supplier on-boarding process more efficient (Pearce, 2018).

Figure 6.2e Supplier data management process in tactical procurement process (own content)

6.4.6 Automated Supplier Evaluation

Supplier evaluation is a very important step of tactical procurement, it gives the companies a guideline, as to which suppliers should be given the business. If the suppliers are not evaluated correctly, it can make the whole business prone to risks. One should not give an assignment to a supplier who is not very capable for that specific job. In recent years, there have been incidents where the wrong suppliers have damaged companies' reputation. The suppliers are evaluated under certain criteria, which are pre-defined by the companies depending on their requirements and priorities.

In supplier evaluation process, the suppliers are classified into A, B & C suppliers, which shows the importance of those suppliers to the business. Category A suppliers are the preferred

suppliers with whom the companies are involved on regular basis and contribute upto 80% of total companies procured volume and so on.

Figure 6.2f Supplier evaluation process in tactical procurement process (own content)

The ideal solution would be to automate the entire S2C process with one software solution, which could be connected with the automated P2P process as well. The companies who want to embrace digitization should think of one solution which could not only automate the tactical procurement but rather the whole procurement as one, as shown in figure 6.3

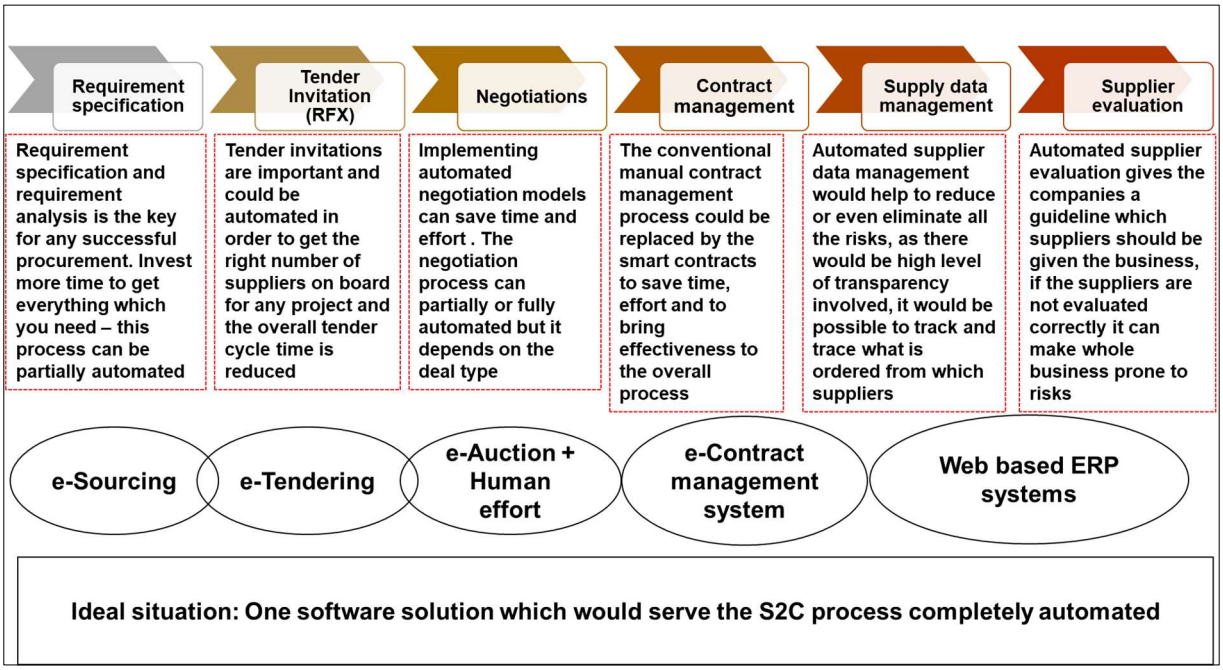


Figure 6.3 One software solution for the whole tactical procurement process (own content)

6.5 Benefits of the Proposed Solution

As procurement automation is the need of time, the companies who would not automate will remain far behind and run out of business (Grassl, 2015). Benefits of the automation which will mitigate the risks are discussed below.

I. Cost Reduction

The primary goal of any procurement is to generate more savings, and the automation of the processes will achieve this target as it has a direct impact on savings, costs reductions and cost avoidance. The automation of procurement processes could make the business, to save in millions by reducing Maverick Buying, long processes, waiting times, reworks, and manual tasks (myInvenio, 2019).

II. Optimized Workflows

The automation of the S2C processes will optimize and streamline the existing workflows, as the S2C processes requires a lot of collaboration and cooperation among the teams. As such optimization of workflows will ensure the success of the procurement processes. This will enable the procurement to trace and track the approved suppliers, the SRM, prices, the agreed terms & conditions, and possible bottlenecks. It will also enable the stakeholders including suppliers to view the process flows in real time, which will lead to better cooperation between all departments (Freer, 2017).

III. Improved Supplier Relationship Management

Good supplier relationship management is the key to success of any procurement organization. This is considered as a top priority in the strategic procurement. The automation of the supplier management will provide the basis to work with the right suppliers. By having the right suppliers in the system, the overall trust level will be increased.

IV. Reduced Process and Communication Time

One of the most important part in procurement is time, the more time you waste the more your procurement loses. This time could be the process-cycle time or the communication time with suppliers or with the internal stakeholders. The automation of S2C process will reduce the communication time between the procurement and the suppliers, as well as within the execution of processes, leading to the overall success of the organization.

Some researchers show that typical communication calls between the supplier and the procurement takes an average of 6 minutes per call for basic interaction (Claritum, 2018). So, if the communication is reduced even to 3 minutes per call, it will have a tremendous impact on the performance of the procurement.

V. Budget Control & Reduced Invoice Costs

Another important benefit of the S2C automation would be to have a good grip and control over the budget, the overall funds will be tracked and traced more efficiently. If your invoices are automated, the invoice costs will be reduced immensely (Palettesoftware, 2016).

VI. Transparent Cash Flows

With the manual process, it is difficult to achieve efficient and effective results, but with the automation of the processes, transparent cash flows can be achieved. It will bring clarity to the process, as to who is buying what, at which cost, and under which term & conditions. The automation of this process can provide better cash management and impressive earnings growth for any organization.

VII. Improved Transparency Level

The automation of the S2C process will increase the transparency level. If information is considered as power, then the transparent information could be considered as super-power. Improved transparency can have an impact on all the steps of the S2C procurement processes.

VIII. Solid Basis for P2P Processes

The P2P process is the implementation playground of the S2C processes, if your S2C processes are automated, transparent, and up to mark, automatically your P2P processes will be improved and will be the Best in Class. On the other hand, with the P2P automation the end user is automatically empowered. The users will be provided with electronic catalogues, from which they can select their required products easily. With electronic catalogues, the suppliers offer and provide products electronically. This ensures more visibility to the buyers into product and price information (Matters, 2017).

IX. Reduced Maverick Buying

As Maverick Buying causes spend "leakage", it affects the spend transparency because of the usage of non-contracted standard suppliers (Rogers, 2021). If you do not have total spend visibility, you cannot perform effective spend analysis, and organizational money is wasted, proper data management is compromised and above all the risk of non-compliance increases (Biedron, 2018). As the automation of S2C processes increases the transparency level of the spend, thus the Maverick Buying could be significantly reduced.

6.6 Limitations of the Proposed Concept

On one hand if the proposed concept of automation of S2C processes could bring many benefits to an organization, on the other hand there are some challenges associated with the proposed model; they are explained below

a. Limited Automation:

The proposed concept cannot be fully automated as the tactical procurement process steps involve human interactions; these human interactions cannot be eliminated from the process. The only part which could be automated is the supplier management, but it also requires human interactions for tendering, requirement specification, negotiation, and contract management.

b. Educating the teams:

It is always a challenge to introduce some new technology in a team, but when it comes to getting your team embrace the automation of such complex processes, it will always be a challenge and will require more time, effort, and costs.

c. Process complexity:

The proposed concept involves the automation of all different steps of the tactical procurement, which makes it more complex in terms of execution and implementation. Also, the implementation costs of such a complex process will be high.

6.7 Chapter Conclusion

Tactical Procurement defines short terms strategies and plans up to 1 year to keep your business running smoothly and it consists of different independent processes. The tactical procurement is one of the bases for the execution of operational procurement processes. So, if the S2C processes are in the wrong direction, the overall procurement performance will be affected. If the companies and organizations want to progress at the same pace with the digital

revolution of the world, these processes of the tactical procurement will have to be automated. The automation of the S2C processes will not only reduce the costs but will increase the transparency level of the spend. The contracts will be efficiently managed, the right suppliers who can do the job better will be taken on board, the risks of the manual processes will be mitigated, a great amount of time will be saved, the overall performance of the organization will be improved and above all a solid platform for the automated P2P processes will be set.

Chapter 7: Automation of Spend Management Process

The digital revolution is compelling the businesses to work in collaboration to achieve their targets because it is getting almost impossible for companies to survive independently. These collaborations lead to the complexities of the processes which can result in in-transparencies in the process flows and spend management. A proper, clear, and transparent spend management is the key to the success of any organization and an uncontrolled, unclear spend management can lead the companies to bankruptcies.

Spend management is a vital part of the strategic procurement and it is important to keep a constant and transparent track of the spend in any organization.

In this chapter it has been shown how automation concepts can contribute to mitigate the risks associated with spend management. Furthermore, the conventional spend management processes in procurement have been explained in detail, and at the end the conventional / manual spend management processes have been compared with the proposed automated concept. It has also been identified which benefits could be achieved by our proposed concept.

7.1 Strategic Procurement

It is also known as P2S (Plan to Strategy). It refers to long term organization-wide plans to ensure timely supply of goods and services which are critical to the business (Business, 2017). It also focuses on reducing suppliers, identifying critical suppliers, and maintaining long term relationships with strategic suppliers (CIPS, 2009). This type of procurement is the most important type of procurement, it deals with the overall strategic topics and has the biggest impact on cost saving. The typical steps of a P2S process are: Spend Analysis and Management, Demand Management, Market Analysis, Material Group Strategy, Supplier Qualification, Supplier Risk Analysis, Supplier Development. Figure 7.1 shows a typical strategic procurement process.

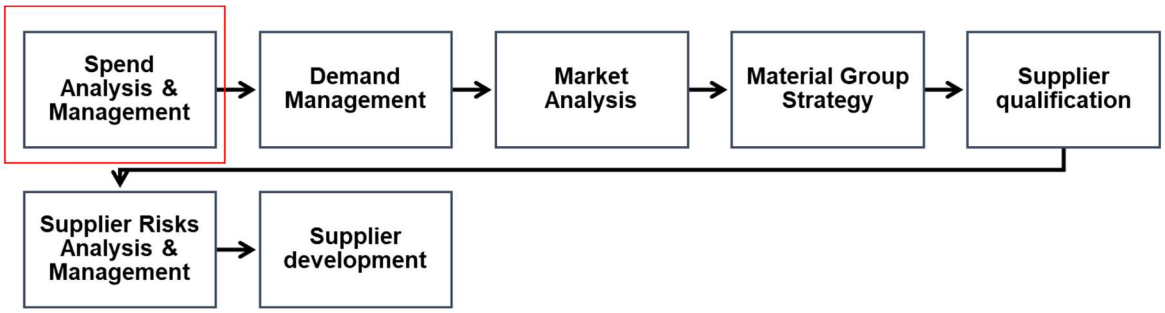


Figure 7.1 Typical strategic procurement process: figure based on (amc, 2017) *&* (Rendon, 2005) *with modifications*

7.2 Spend Analysis and Management

The main purpose of the spend analysis and management is to achieve a complete visibility of your spend (Sorgi, 2020). Spend analysis is the process of identifying, gathering, cleansing, grouping, categorizing, and analysing the spend data of an organization with a goal of

decreasing procurement costs and improving efficiencies (Jagger, 2016). It is important to analyse the spend in every organization first, only then it could be managed properly. A proper spend analysis process provides the base to reduce the procurement costs, increases the organizational efficiency and improves the supplier relationship. It also provides reliable data to plan strategies to achieve short- and long-term savings. The process of spend analysis provides answers to questions (a) what are being bought? (b) Who is buying it? (c) From whom are we buying it? (d) How much do we pay for it? (e) When did we buy it? (f) Where were the items delivered? (g) Did we get what had been promised? (h) Who is paying for it? (Sievo, 2019).

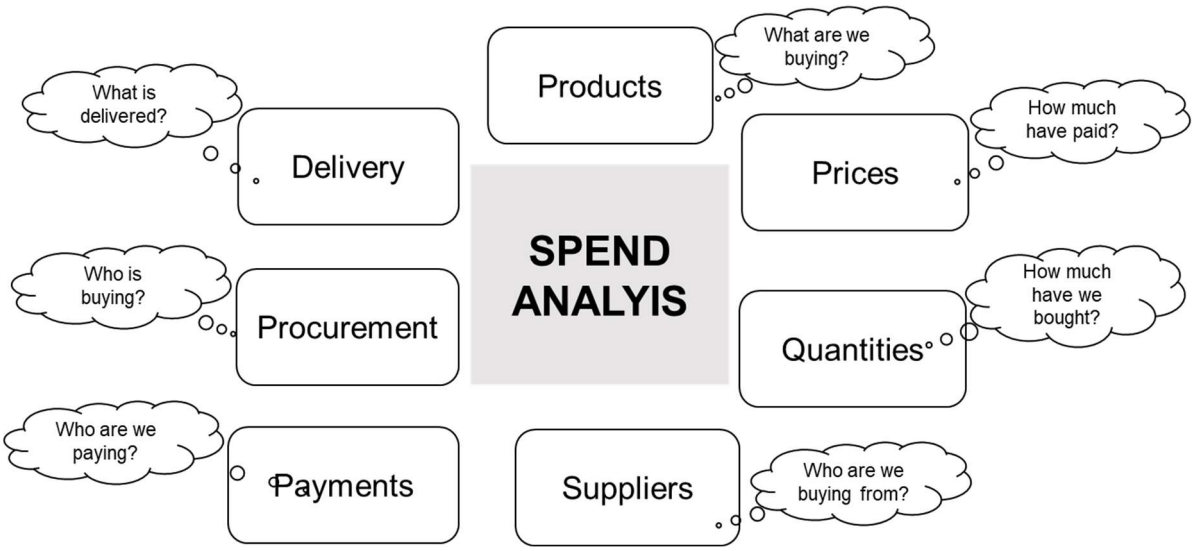


Figure 7.2 Spend analysis questions: figure based on (Sievo, 2019) *with modifications*

7.2.1 Types of Spend

It is important for the business to identify where the spend is taking place. Controlling the spend is an art which helps organizations to achieve their targets. Spend is normally divided into two types which makes it easy to track and trace and, in some organizations, there are different procurement managers who control these spends separately to ensure better control.

1) Direct Spend

Direct spend is also called direct procurement. It refers to the purchase of goods and services which are directly related and are incorporated to a product being manufactured i.e., **raw materials, components, hardware, manufacturing equipment etc**. (Dominick, 2019). Normally these procurements are carried out in large quantities and are acquired from the best possible suppliers at the best possible prices with the right quality and quantity.

2) In-direct Spend

In-direct spend is also known as in-direct procurement, it refers to the purchase of goods and services which are not directly related and are not incorporated into a product being manufactured i.e., **computers, software, office supplies, equipment, marketing services, consultancy services, utilities etc**. (Dominick, 2019). The indirect spend is prone to many

risks. One of the important risks among them is Maverick Buying, which can lead to uncontrolled and In-transparent spend.

7.2.2 Spend Management KPI's

Organizations in this world perform in different styles and that is how they have different priorities, which makes it difficult to set standard KPI's for all types of businesses. Although there are some general best-practices, but it is extremely important for any organization to identify their KPI's to serve their purpose. Below are some of the most important KPI's which could be important for any type of business, and I will use some of these KPI's to perform my experiments which fits to my proposed solution.

A. Savings (the most important which every organization wants)
B. Cost reduction (extremely important to find ways to reduce costs)
C. Maverick Buying (the main issue in big companies)
D. Supplier management (highly important for the success of any organization)

7.2.3 Spend Analysis Process

The spend analysis process works in a systematic way, all the data is collected to a master database and the steps involved in spend analysis are shown in Figure 7.3.

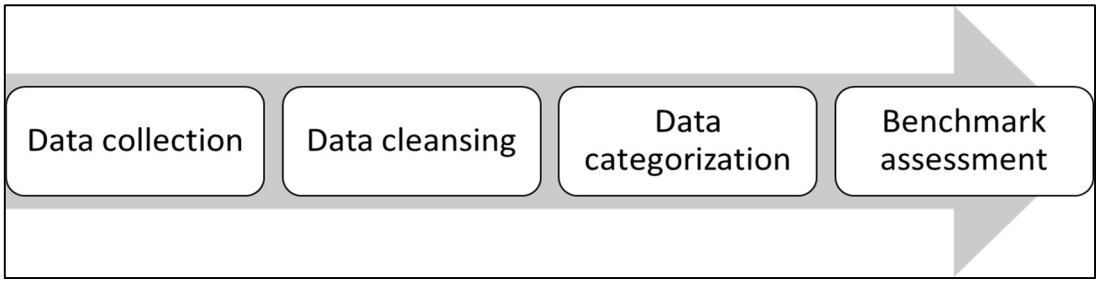


Figure. 7.3. Spend analysis steps (own content)

a. Data Collection

Data collection is the base for achieving the best result in spend analysis, the stronger the base the better the result. The data is collected from different sources and is arranged in a standard pre-defined format depending on the requirement of the company, where the scope and focus area of the business is defined and all the important open questions related to the data are answered.

b. Data Cleansing

The data collected is not always clean, it contains many typos, errors, incomplete, incorrect, and irrelevant information, which needs to be corrected. In this step of the process, the data is cleaned and any typos, misspellings etc. are rectified. In many companies, the data scientists are the people who perform such activities and clean the data. Clean and accurate data provides a strong base to the overall spend analysis.

c. Data Categorization

In this step of the process, the data is categorized and divided into different categories, which are related to the business. Every business operates in a different way, and most of the companies have divided their products in main categories and sub-categories. This is important step for the spend analysis and shows how much of the spend is spent in that category, this exercise provides a solid base for category management.

d. Benchmark Assessment

In this process step, the data is compared against the benchmarks developed by the companies depending on their KPIs. Every company has its own priorities in terms of spend and savings, every now and then, they work with the benchmarks and KPIs to achieve their targets. The benchmark assessment phase provides a ground for comparison.

7.3 Risks of Improper Spend Management Processes

A proper spend management is key to the success of every organization and this can work as a door opener for costs savings, but still many big companies do not invest time and effort in this area. Below are some of the prominent risks associated with spend management.

I. Uncontrolled Spend

One of the biggest risks to in-transparent spend management process is the uncontrolled spend also called “Maverick Buying”. Maverick Buying is one of the biggest threats to any procurement organization, because Maverick Buying simply bypasses the procurement processes and procedures, contracts, negotiations, price comparisons, contract agreements etc. (Linda, 2019).

Maverick buying has adverse effects on any organization and can push any company closer to the brink of bankruptcy, because it costs you time, money, manpower to perform the purchasing tasks and if the companies do not have total spend visibility, they cannot perform effective spend analysis. Organizational money is wasted, proper data management is compromised and above all the risk of non-compliance increases (Biedron, 2018).

II. Low Transparency

One of the major risks of improper spend management is the low transparency of spend, it means that the organizations do not have the correct overview of where they are spending? how much and why they are spending. This low transparency could lead the businesses to heavy losses and even to bankruptcy.

III. Increased Overall Spend

The unmanaged spend could result in an increased overall spend of any organization. As there will be low visibility of spend there are high possibilities of incurring wrong spends which automatically increases the overall spend.

IV. Poor Supplier Management

The spend is directly related to suppliers, if there is no visibility of the spend it will directly influence the supplier management process, which can increase the risk of poor organizational performance.

V. Frauds, Misuse, Non-Compliance

The unmanaged spend can be a door opener to fraud, misuse and non-compliance, there are many incidents observed in recent years that the managers have misused the money of their organizations. This can have a huge impact on the company's overall savings as well as reputation.

VI. Poor Claim Management

Claims are directly related to spend; an improper and non-transparent spend management can result in poor claim management.

7.4 Proposed Automated Spend Management Process

In the proposed concept, it has been tried to achieve an automated spend management process which will provide more visibility of the spend of any organization; the data will be properly analysed and different automated reports for management will be processed. This solution will contribute to the overall performance of any supply chain. The proposed concept is embedded with an automated P2P process. The automated P2P process is the prerequisite to implement an automated spend management process, because the actual spend takes place in the P2P process.

Figure 7.4. shows a typical automated P2P process, the exchange of documents across all nodes are electronic, the invoices are automated, and the payments are executed electronically.

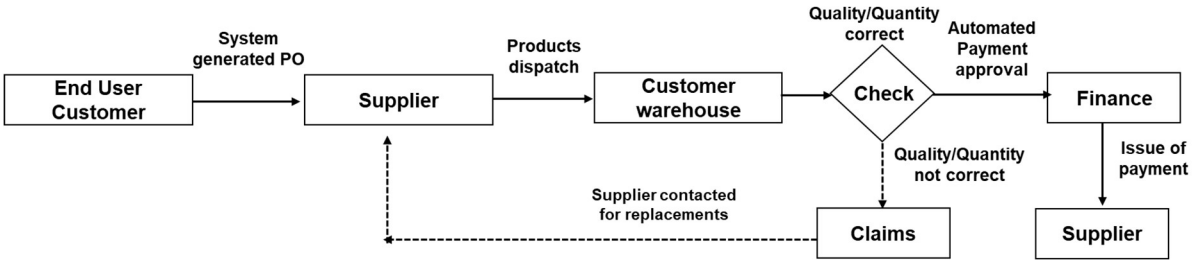


Figure. 7.4 Automated P2P process execution cycle (own content)

The end-user is provided with a software-based catalogue platform, which includes information regarding the preferred suppliers, products, prices, product availability, expected delivery dates etc. It provides the freedom to the end user to choose which product and supplier fits his/her requirements the best.

The end user selects his/her choices, which suit him/her the best and once he/she orders, the products an automated purchase order (PO) is sent to the selected supplier, simultaneously the same information in a predefined structure will be stored in a Master database as data

points. Master database is part of the solution, and it is the database where all the information is stored which are associated with the complete purchasing process.

As a next step the supplier will receive the automated POs and will dispatch the required products/items to the end customer along with an automated electronic invoice. As soon as the goods leave the warehouse of the supplier the dispatch information will be automatically uploaded to the master database in form data points.

In the next step the goods / products will be received at the customer warehouse. Upon the receipt of the goods, the exact arrival dates, quality, and quantity information will be recorded in the automated P2P software, while on the other hand the same information will be uploaded to the master database as data points.

Next, if the quality, quantity, and any other variables, which are set by the business as product acceptance criteria, are fulfilled, an automated payment approval will be sent to the finance department and the finance department will issue the payments to the suppliers. The same information will also be recorded at the master database as data points.

By now, an automated successful P2P cycle is executed, and all the related information are recorded in the master database as data points. The master database will store every small data point related to the spend, as data is power so the master database in our solution is the powerhouse.

The master database will have the ability and capability to store all the information in a user-defined structure. The master database with all the information is connected to the actual automated spend management solution which will provide us the basis for the spend analysis and to find answers to the questions **like "what am I spending?", "where am I spending?", "why am I spending?"** etc. The proposed concept is shown in the figure 7.5. along with the explanation of the automated spend management process.

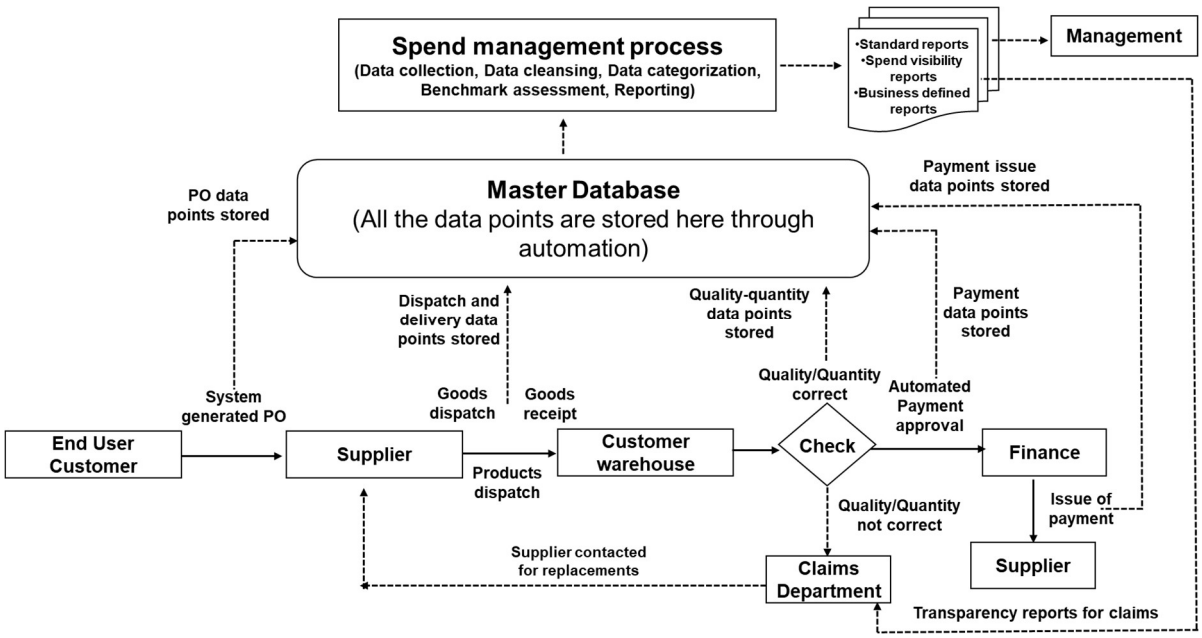


Figure 7.5. Proposed automated spend management process (own content)

The proposed automated spend management solution will be capable to perform all the spend management steps in an automated way and will be performed in the following steps.

I. Data Collection/ Data Acquisition

The first step is the data collection. In the conventional methods, the raw data is collected from different sources, but in the proposed concept, the single source of information is the master database, all the data will be collected from the master database and this process will work in automated way.

II. Data Cleansing

It is the most important step of the spend management, here all the data will go through a cleansing process where all the errors and unwanted information will be eliminated. The data quality is very important to be achieved and can be measured with criteria like **validity of data**, **accuracy of data**, **consistency of data** and **completeness of data**.

Data cleansing is a repetitive process, it will be performed every time when a new data point enters the solution, this step is fully dependent on the business's requirement, and can vary from business to business because every business has its own priorities in terms of spend.

III. Data Categorization or Data Classification

In this step the data/spend is categorized according to products, items, spend categories etc. it means, which spend belongs to which product or category? This step already is a deep dive in the data visibility. The outcome of this step can vary from business to business.

IV. Benchmark Assessment

As next step, the benchmark assessment of the data will take place; analysis against the benchmark will be performed. Every business has its own benchmarks in place depending on their priorities. The prime goal of benchmarking is the continues improvement of the processes. Benchmarking provides you the base to look at your performance in comparison to your competition and identifies where you want to reach. For this you set your main targets and goals and design small iterations to achieve your goals.

V. Reporting

In the final step, different automated reports, dashboards, analysis, saving opportunities etc. are sent to management for their decision-making. These reports could be defined by the businesses themselves and vary from business to business.

The proposed automated solution brings effective and efficient spend visibility to the overall spend of any organization. The P2P process will be automated, and all the data will be stored in the master database, which is the single source of truth, that is why the chances of errors are reduced. Above all the solution will provide automated monthly, quarterly, yearly spend reports to the management for better decision-making. This process will also save a lot of time, bring value, transparency and will reduce the risks.

7.5 Benefits of the Proposed Solution

Benefits of the automation which will mitigate the risks are described below.

I. Improved Spend Transparency and Visibility

The automation of the send management processes will increase the transparency level of the spend. All these questions like what are we buying? Who are we buying from? Why are we buying? Who is buying what at which cost? Are we getting what we have been promised for? How are we performing in comparison to previous years? will be answered with the proposed solution.

II. Controlled Spend

When the businesses don not have total spend visibility, they cannot perform effective spend analysis. Organizational money is wasted, proper data management is compromised and above all the risk of non-compliance increases (Biedron, 2018). With automation of the spend management processes, the transparency level of spend increases, it becomes clear who is buying what from whom at which price, thus the Maverick Buying could be significantly reduced.

Many buyers as well as suppliers who use spend analytics solutions and transactional purchasing systems associate Maverick spend reduction as the benefit of their solution (Rogers, 2021).

III. Saving Opportunities and Cost Reduction

The primary goal of any procurement is to generate more savings. The automation of the processes will achieve this directly as it has a direct impact on savings, costs reductions, cost, and avoidance. The automation of process can make the businesses to save in millions by reducing long processes, waiting times, reworks, manual tasks (myInvenio, 2019).

IV. Improved Supplier Relationship Management and Performance

The automation of this process will provide the basis to identify you preferred and strategic suppliers in terms of spend based on this the supplier management strategy should be established. A good supplier relationship management is the key to the success of any procurement organization, and this is considered as a top priority in the strategic procurement. The automation of the supplier management will provide the basis to work with the right suppliers. By having the right suppliers in the system, the overall trust level will be increased.

V. Transparent Cash Flows

With the manual processes, it is difficult to achieve efficient and effective company cash flows, but with the automation of the processes, businesses can achieve transparent cash flows; it brings clarity who is buying what at which prices under which term & conditions. The automation of the processes can provide better cash management and impressive earnings growth for organization.

7.6 Experiments

In this section, I have performed some experiments to show how my proposed solution is better than the traditional spend management or semi-automated process. The automation of

processes is performed in excel. The data used here is from an actual company but due to NDA issues, I have changed the names, categories and figures and have made the information anonymous.

7.6.1 Problem Statement

The Company operates in 11 different countries in Europe with its Head-office in Germany. The company is buying different products in 3 categories i.e., IT infrastructure, Software, and Services for its internal use as well as for its customers. The company was dealing with more than 4500 suppliers and resellers. These 11 countries do not use the same software to capture, control data, store records and information. Because of the size of the company, the procurement department was prone to many risks and they were facing a huge problem to identify and control their spend. I worked on their data and implemented it in my proposed automated concept to see how my concept works to highlight their issues and generates management reports. I got access to their data of 2 years and I performed different experiments with the help of Microsoft excel to generate different reports and to optimize the spend and named the solution “Spend Cube”. The final solution concept is presented in figure 7.6

7.6.2 Solution

To perform the analysis, the spend data from all the business units from all these 11 countries was gathered. The data was quite messy because every business unit used their own way of gathering the data and below were the main targets identified for the solution.

- There are different available sources of information; we have to utilize these information sources to develop the new products.
- The products, which are to be developed, should be complete and transparent.
- The products should be easy to understand and should have a high degree of usability.

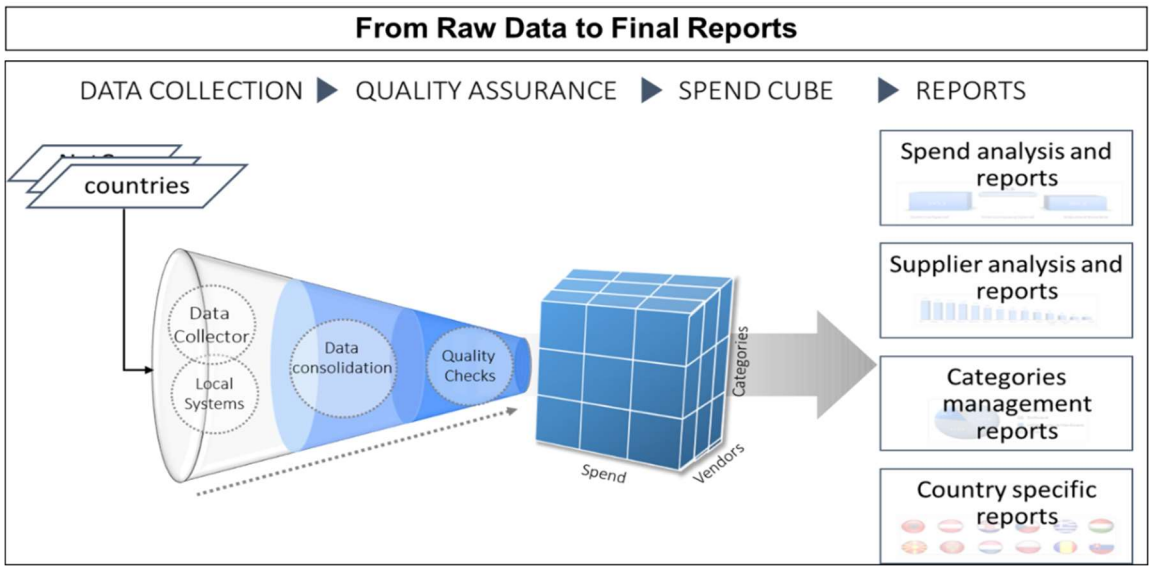


Figure 7.6. Approach to the final solution (own content)

The approach of the solution is mentioned in figure 7.6 and the process was completed in below 4 Phases:

A. Data Collection
B. Data Consolidation
C. Data Harmonization
D. Data Analysis

A. Data Collection

In any type of data analysis, the data collection is the first and most important step. One has to spend almost 30% of the total project time to get the right data, because garbage-in garbage-out. In order to get the right data from business units a standard excel sheet was designed which included all the necessary information which were required for my analysis. The excel sheet was named as data collector. All the business units were requested to provide the spend information in the required format. In some cases, some of the countries did not provide the data in my required format; rather they sent it in their format per email, which I had to modify in accordance with the standard data collector. The data collector included information below, and the sample data collector is shown in figure 7.7.

- Spend in €
- Vendor/Supplier Name
- Manufacturer Name
- Main Category
- Subcategory
- Business unit / Domain
- Dates
- General Remarks

DATA COLLECTOR						
VENDOR AND SPEND INFORMATION			CATEGORY AND DOMAIN INFORMATION			
Vendor	Manufacturer	Spend	Main Category	Sub-Category	Domain	Date
The vendor for the product which has been purchased	The manufacturer name in case the product is purchased via a distributor	The total amount of invoiced spend in €	Main category i.e., IT Infrastructure, Software, Service	Sub-category to specify the details of the products, services	The information regarding the Domain for which the product has been purchased	The of purchase and invoice

Figure 7.7. The data collector (own content)

Along with the data collector, the main categories and sub-categories were also defined and communicated to all the participant countries. The idea behind was to get as much as information possible in the right way, this division of categories and sub-categories is shown in table 7.1

Standardization of Categories and Sub-categories			
Main Category	**Sub-categories**		
1. IT Infrastructure	1.1 Rent	1.2. Utilities	1.3. Maintenance
	1.4. Servers	1.5. Storage	1.6. Office equipment
	1.7. Network	1.8. Contract maintenance	1.9. Licenses
2. Software	2.1. Application licenses	2.2. Application maintenance	2.3. Database licenses
	2.4. Database maintenance	2.5. System management licenses	2.6. System management maintenance
	2.7. Desktop application Licenses	2.8. Desktop application maintenance	2.9. Software development
3. Services	3.1. System integration	3.2. Development and testing	3.3. Infrastructure operations
	3.4. Application operations	3.5. Communication infrastructure	3.6. Fully managed services
	3.7. Consulting		

Table 7.1. Standardization of categories and sub-categories (own content)

The data collection was not an easy task and was performed in a close coordination and cooperation with all the countries in order to make sure that nothing is missed, some of the main issues faced in the data collection phase are mentioned below. A communication with the participated countries was established, all these different countries were invited to participation calls, where the timeline and other information were shared. POC's were identified in each country to support this transformation. Almost all the participated countries agreed on below points.

- Future analysis should be automated to a maximum level and the manual inputs should be minimized
- Standard and user defined analyses were identified and discussed in detail
- Timeline for data collection from the countries was agreed
- Automation concepts of the reporting were discussed

Issues Faced in Data Collection Phase

- Data collection is the base for developing the best result, "the stronger the base the better the result"
- Most of the issues have been observed in the data collection phase
- Data was not 100% delivered in the required format of the Data Collector
- Many countries delivered incomplete information e.g., no clear material codes numbers for all the spend, no subcategories
- No clear general remarks for the spend
- One material code number with different remarks, which makes the matching difficult
- Delays in data: Some of the countries did not deliver the spend information on time, which delayed the development of the Spend Cube
- Some countries conveyed corrections in the middle of the Spend Cube development process, which resulted in duplication of work and delays

B. Data Consolidation

In this phase, all the data, which was received from all these countries was consolidated in one excel sheet in the identical format, all the required segments were identified and matched, and this sheet was named as the Master File. Consolidation of submitted spend-reports was stored in the Data Collector format in one common database.

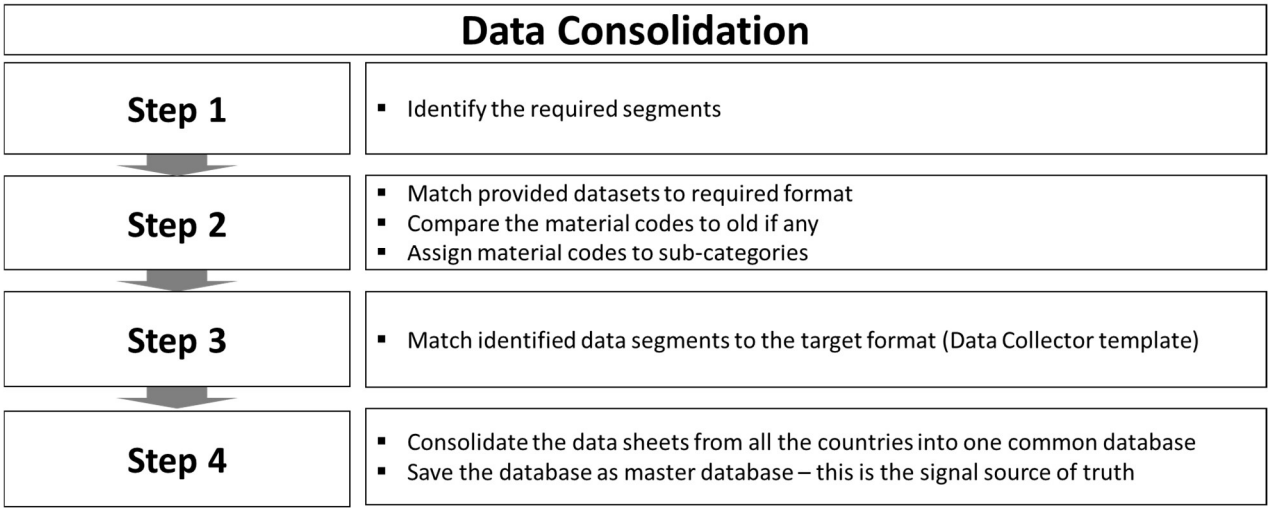


Figure 7.8. Data consolidation steps (own content)

C. Data Harmonization

In this phase, the provided data was harmonized for cross country comparison and analytics. The country-specific supplier names were matched to cross company supplier names. This was an important step to provide a solid base to the analytics part. As already mentioned above, the company works with more than 4500 suppliers, and most of these suppliers have global presence. In the data harmonization part, it was revealed that many suppliers were working for different countries, but their names were mentioned differently across the company, so all those suppliers were harmonized with the cross-company names. Further, the classification of harmonized suppliers above 10k spend was performed

D. Data Analysis

In the Data Analysis phase, based on the final sorted data, different analyses were performed which are listed below. All these reports were connected to different Power Point presentations by the help of Macros. The background was to provide only few click buttons to the management to extract these reports easily.

a) EU ABC Analysis (for all spend and for spend above 10k€)
b) ABC Analysis per country (for all spend and for spend above 10k€)
c) EU ABC Analysis in comparison with previous years
d) TOP 20 Spend per country
e) Spend identification Internal vs. External
f) Supplier analysis (supplier per country)
g) Top 20 suppliers in terms of spend per country
h) Comparison of top 20 suppliers with previous years
i) Unique vs. overlapping suppliers per country

j) Unique vs. overlapping suppliers per category
k) Top 20 suppliers per category
l) Total spends per category
m) Identification of Maverick Buying

7.6.3 RESULTS

The concept was implemented for all the 11 Countries in Microsoft Excel, the above-mentioned analyses were performed, and automated reports were created. A reporting dashboard was designed shown in figure 7.9 below, where the users have to select a specific country from a drop-down list and automated reports were generated and incorporated into power point presentation in a predefined format. Besides this, some other management dashboards were also defined to ensure high-level management reports.

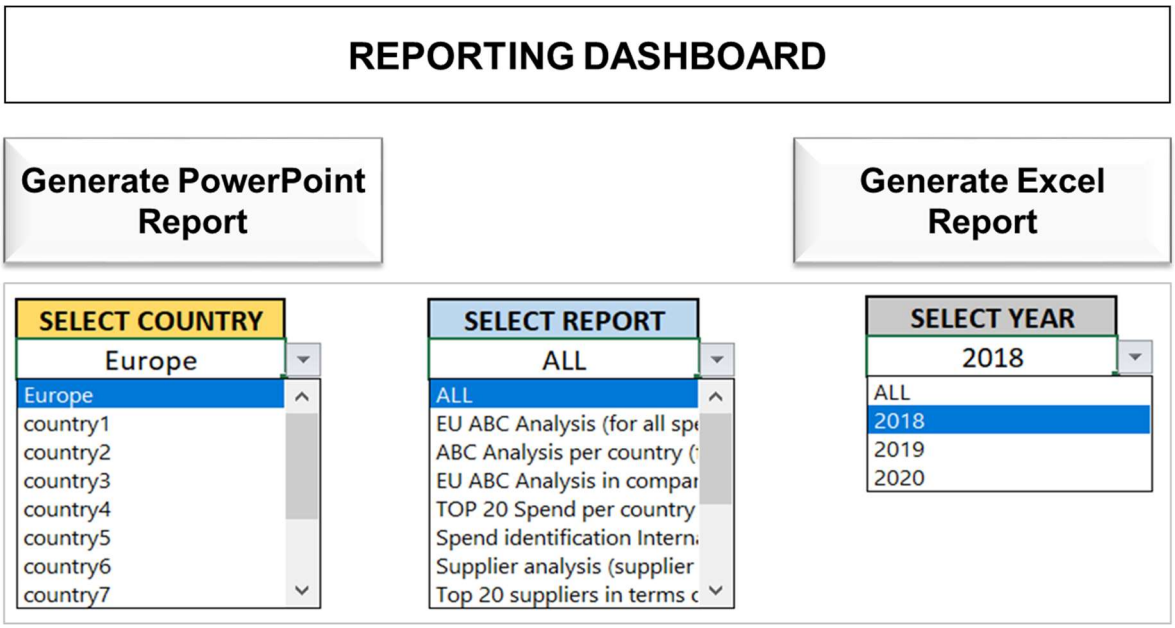


Figure 7.9. Reporting dashboard (own content)

To show some results here, I have taken only one country as an example and have replaced the actual country's name by "Country1". Figure 7.10 (on the next page) shows a comparison total spend of Country1 against the spend of all the 11 countries. The trend shows that the spend of Country1 in 2018 and 2019 is almost the same.

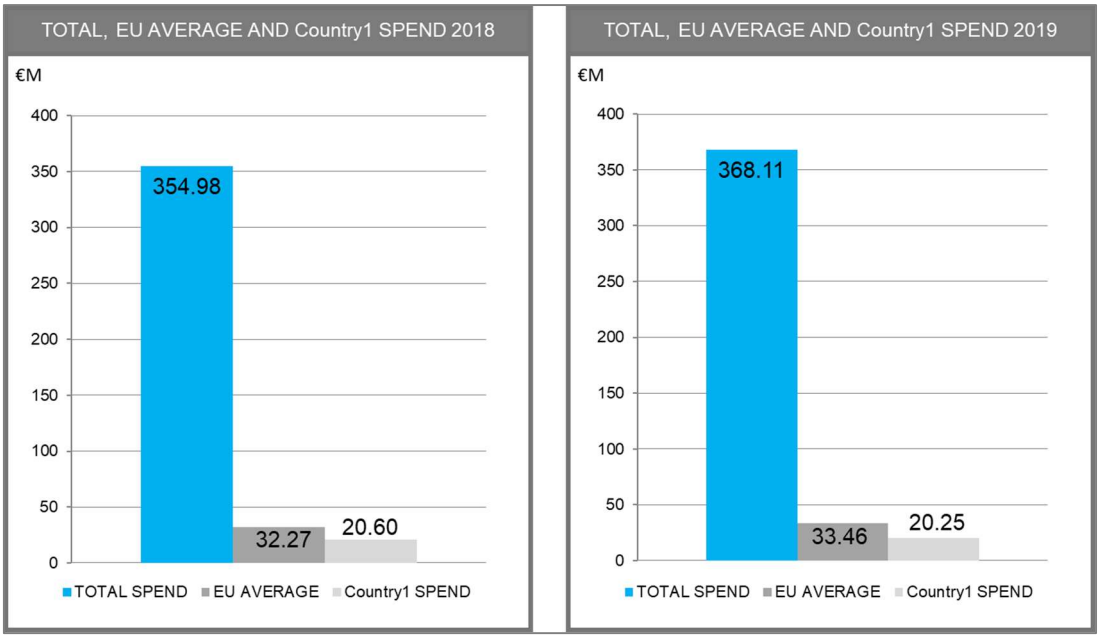


Figure 7.10. Total spend, EU average and Country1 spend 2018 vs. 2019 (own content)

Figure 7.11 below reflects the spend of Country1 in each product category against the average spend of all the 11 countries. This deep dive provides a trend, how the spend is growing in which category from 2018 to 2019, this report also provides a base to the management to see if Country1 is spending more or less in comparison to other countries and can investigate it further and can find measures to meet the company's targets.

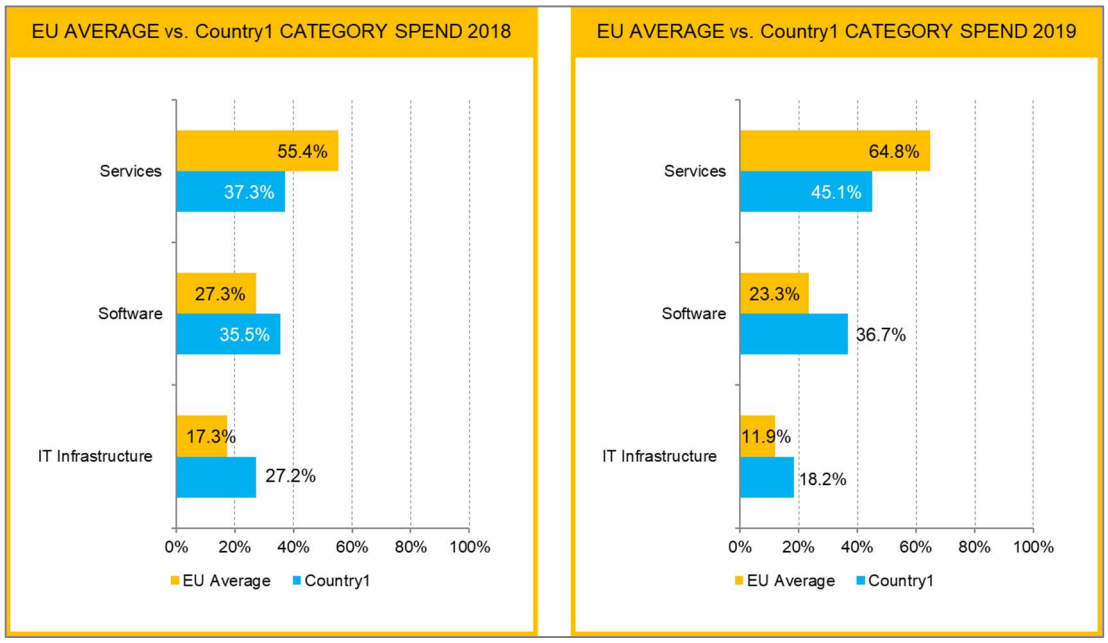


Figure 7.11 Total spend vs. EU average category spend 2018 vs. 2019 (own content)

Figure 7.12 below provides the information regarding the top 20 vendors/suppliers in terms of spend for Country1.

This information is very important for the supplier management, the management now knows, with which suppliers are they spending how much, the spend of each supplier is compared to the total spend of Country1. The analysis showed that in 2018, around 38% of the overall spend took place with the top 3 suppliers. The analysis also showed that the top 2 suppliers for Country1 in 2018 and 2019 remained unchanged.

TOP 20 VENDORS 2018

No	VENDOR	SPEND (€)	%
1	Not allowed to share vendors names but the top 2 suppliers remained unchannged only the spend assoicated to them changed from 2018 to 2019	11.694.245 €	21,5%
2		4.317.470 €	7,9%
3		3.808.501 €	7,0%
4		3.641.712 €	6,7%
5		2.472.434 €	4,5%
6		2.363.310 €	4,3%
7		1.789.174 €	3,3%
8		1.737.628 €	3,2%
9		1.707.182 €	3,1%
10		1.429.395 €	2,6%
11		1.347.449 €	2,5%
12		1.250.109 €	2,3%
13		1.109.073 €	2,0%
14		881.902 €	1,6%
15		831.962 €	1,5%
16		671.055 €	1,2%
17		651.039 €	1,2%
18		510.431 €	0,9%
19		503.335 €	0,9%
20		392.809 €	0,7%

TOP 20 VENDORS 2019

No	VENDOR	SPEND (€)	%
1	Not allowed to share vendors names but the top 2 suppliers remained unchannged only the spend assoicated to them changed from 2018 to 2019	7.666.294 €	12,8%
2		6.369.375 €	10,7%
3		6.121.712 €	10,2%
4		3.527.201 €	5,9%
5		3.336.801 €	5,6%
6		3.168.237 €	5,3%
7		2.442.765 €	4,1%
8		1.959.574 €	3,3%
9		1.813.833 €	3,0%
10		1.773.029 €	3,0%
11		1.677.842 €	2,8%
12		1.148.052 €	1,9%
13		1.044.221 €	1,7%
14		1.023.074 €	1,7%
15		713.801 €	1,2%
16		644.486 €	1,1%
17		614.405 €	1,0%
18		547.248 €	0,9%
19		537.986 €	0,9%
20		506.720 €	0,8%

Figure 7.12 top 20 vendors 2018 vs. 2019 in all categories for Country1 (own content)

Figures 7.13 a, b and c show the top 20 vendors in terms of spend in 2019 in different categories, this information is also very valuable for the managers, as it shows the trend of spend according to different categories. Similar reports with comparison of 2019 vs 2018 were also automatically generated for the managers to have an eye on the development of the overall spend trend.

TOP 20 VENDORS – SERVICES - 2019

No	VENDOR	SPEND (€)	%
1	Not allowed to share vendors names	7.605.803 €	14,5%
2		6.369.375 €	12,2%
3		6.017.768 €	11,5%
4		3.527.201 €	6,7%
5		3.330.381 €	6,4%
6		2.377.798 €	4,5%
7		1.959.574 €	3,7%
8		1.773.029 €	3,4%
9		1.665.471 €	3,2%
10		1.117.525 €	2,1%
11		1.021.776 €	1,9%
12		1.011.131 €	1,9%
13		713.801 €	1,4%
14		667.560 €	1,3%
15		644.486 €	1,2%
16		614.405 €	1,2%
17		537.986 €	1,0%
18		513.628 €	1,0%
19		457.719 €	0,9%
20		389.928 €	0,7%

Figure 7.13a top 20 vendors 2019 in service category (own content)

TOP 20 VENDORS – SOFTWARE - 2019

No	VENDOR	SPEND (€)	%
1	Not allowed to share vendors names	2.535.685 €	46,7%
2		1.146.273 €	21,1%
3		307.826 €	5,7%
4		228.149 €	4,2%
5		201.057 €	3,7%
6		158.197 €	2,9%
7		148.070 €	2,7%
8		120.742 €	2,2%
9		72.463 €	1,3%
10		60.492 €	1,1%
11		58.632 €	1,1%
12		49.706 €	0,9%
13		44.685 €	0,8%
14		44.232 €	0,8%
15		39.062 €	0,7%
16		32.776 €	0,6%
17		31.412 €	0,6%
18		29.210 €	0,5%
19		23.682 €	0,4%
20		23.272 €	0,4%

Figure 7.13b top 20 vendors 2019 in software category (own content)

TOP 20 VENDORS – IT INFRASTRUCTURE-2019

No	VENDOR	SPEND (€)	%
1	Not allowed to share vendors names	220.349 €	9,7%
2		179.274 €	7,9%
3		158.148 €	7,0%
4		143.763 €	6,3%
5		130.107 €	5,7%
6		127.331 €	5,6%
7		118.924 €	5,2%
8		65.870 €	2,9%
9		64.968 €	2,9%
10		63.426 €	2,8%
11		62.327 €	2,8%
12		62.100 €	2,7%
13		56.031 €	2,5%
14		54.794 €	2,4%
15		51.074 €	2,3%
16		46.118 €	2,0%
17		40.167 €	1,8%
18		38.891 €	1,7%
19		36.592 €	1,6%
20		31.545 €	1,4%

Figure 7.13c top 20 vendors 2019 in it infrastructure category (own content)

7.6.4 Key Findings and Recommendations for Country1

The above analysis resulted in some key findings for country1, which are mentioned below, in Table 7.2 along with some recommendations to improve the processes. Same key findings and recommendations were generated for all the 11 countries.

KEY FINDINGS	RECOMMENDATIONS
➢ Increased spend for Services 2018: 77,2% 2019: 87,2% (+10,0%) → above EU average (64,7%)	➢ Take advantage of EU IT Services measure: ▪ Standardize role and skill model ▪ Standardize and optimize contracts ▪ Use existing benchmarks for service contracts to validate rates
➢ Decreased spend for Software 2018: 16,4% 2019: 9,0% (-7,4%) →below EU average (23,4%)	➢ Become part of vendor consolidation measure: ▪ Gain advantage from EU transparency ▪ Optimize A/B vendors (Services) ▪ Optimize SLA contract landscape per domain, vendor, value chain ▪ Reduce long-tail
➢ Decreased spend for IT Infrastructure 2018: 6,4% 2019: 9,2% (-2,8%) → below EU average (11,9%)	➢ Make use of license management risk avoidance service
➢ Top 5 vendors accountable for 45% of total spend, lead by supplier XXX	➢ Use (free) central support to reduce reporting effort
➢ Still high number of vendors from 197 in 2018 to 198 in 2019	

Table 7.2 Key findings and recommendations for Country1 (own content)

Further to the above figures, many other reports, monitoring dashboards, operational dashboards etc. were automatically generated for all the 11 countries. The concept, I proposed

worked in a successful manner and same analyses were created for all the 11 countries. Key findings were identified to the company managers along with my recommendation.

Another interesting finding was that some of the countries were unable to justify and map the spend of around 37% to any material group, nor supplier and was subjected as undefined, that was considered as Maverick Buying. It was a clear drawback of the manual processes used. By implementing my proposed concept, all these underlying issues were highlighted and were brought to management.

The concept was a success, but still the company has not implemented it in a fully automated way, they still use the concept in excel, where I recommended to design a software which could perform these analyses and will save a lot of time and will provide a solid base to supplier management.

The recommendations towards the overall success and for using the solution in a proper way to optimize spend, which were mentioned to the company are given below.

- Increase data quality to improve response rate and uniform category matching
- Quick and sustainable data collection, alignment, and correction due to established counterparts and efficient communication between local Procurement, IT and Finance
- All the countries must provide the spend data
- 100% transparency on vendor
- 100% categorized spend data
- Decrease long-tail, implement European supplier Management, and optimize A/B vendor landscape - Vendor Consolidation and Optimization
- Standardize and reduce high spend within Services - IT Services optimization and spend reduction
- Implement and/or monitor upcoming top vendors - Vendor Task Forces
- Further reduction of resellers – reduce the resellers, focus on direct business
- Reduce number of suppliers, exclude the suppliers where less spend takes and focus on the important ones.
- Sustain collaborative data transparency and quality activities between local and central Procurement, IT and Finance – Data mapping, quality, and transparency
- Set one common spend definition
- Set financial and non-financial KPIs and identify benchmarks

7.7 Limitations of the Proposed Solution

The proposed automated concept of spend management consists of many benefits, but there are some limitations of this concept which are described (on the next page).

a. Implementation Limitation:

The proposed concept can be implemented only in large-scale organizations, where the spend could be in millions and where the organizations deal with a good number of suppliers. The concept is ideal for organizations that deal with procurement of IT hardware for internal consumption as well as reselling.

b. Process Dependency:

The proposed concept is an extension of the automated P2P concept; thus, it is dependent on the input values from the automated P2P process. This concept will only be beneficial when an organization already has an automated P2P process in place.

c. Stakeholder Resistance to Change:

A proper spend management is crucial for any organization, coming up with a new concept could be challenging by stakeholders to accept.

d. Data Related Issues:

The proposed concept deal with data, and if the data quality is poor, it can have a negative impact on the result, one bug in the input can produce wrong reports.

7.8 Chapter Conclusion

Strategic procurement is the most important part of procurement as it deals with the long-term strategies of the business. Most of these strategies revolve around the spend management processes. The digital transformation is considered as a threat by some people, but in fact it is not, rather it must be integrated throughout the supply chain to achieve maximum results. It helps the businesses to improve their performance and savings opportunities but only if the digital transformation is implemented in the right ways.

The world is already progressing into the digital revolution, so most of the industries are moving towards digitization. Supply chain management and procurement organizations are also keeping their pace to remain in the race of digitization; if not, they will stay behind and will be vanished from the scene. Spend management is considered as the most important part of strategic procurement as spend has impact on all the 3 types of procurement processes.

Improper and non-transparent spend management can result in devastating consequences for any organization. Below figure shows, how an automated spend management process can improve the overall situation and achieve the defined KPIs and company targets.

It is the need of time to automate every process of the supply chain and procurement, therefore, the automation of the spend management process will bring many benefits for the organization. The automation of the spend management process will increase the visibility of spend, bring spend transparency, improve the supplier management, and claim management processes and improve the overall performance of the supply chain.

Chapter 8: Claim Management Automation Concept Embedded with P2P

In this chapter, an automation concept for claim management embedded with the automated P2P process has been discussed. The risks associated with the manual claim management process have been elaborated in detail. The focus is further narrowed down to reveal how the risks associated with claim management can be mitigated with the automation and which benefits could be brought to any organization in terms of costs savings, supplier management, spend transparency and supplier performance improvements.

The typical P2P process and its risks are discussed in detail in chapter 5, one additional risk which is “poor claim management base” is added in this chapter. Furthermore, typical organizational scenarios have been taken into consideration as an example to show the impact of the proposed solution.

8.1 Importance of P2P Automation for Claims

Operational procurement commonly known as procure to pay (P2P) is the process of requisitioning, sending purchase orders, receiving goods, and paying for the goods or services needed. The operational procurement starts only after the contracts have been negotiated, agreed, and closed with suppliers. P2P deals with the daily purchasing needs of an organization, it also involves managing deliveries, contracts, and dealings with complaints if any (Lin, 2017). A typical procure to pay process with embedded claim management is shown in figure 8.1.

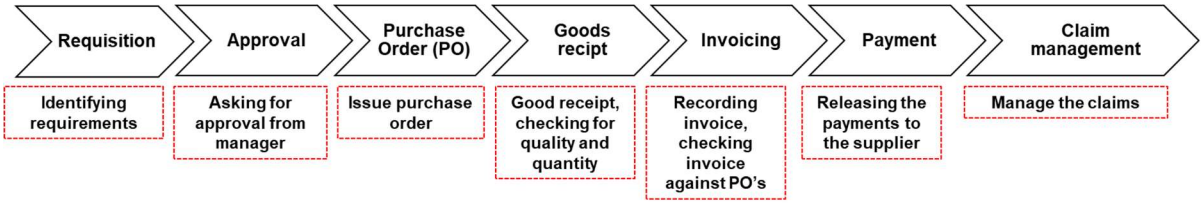


Figure 8.1. Typical “procure to pay” (P2P/R2P) process (own content)

There are companies, that still use the conventional P2P process to meet their operational procurement needs, though the digitization is replacing the conventional procurement methods with automated solutions (Leonard, 2013). To implement the automated claim management concept, it is important to have an automated P2P process in place.

The automated P2P process not only saves a lot of time and effort but also provides a solid base for an improved claim management process. In the proposed concept the P2P process is broken down in blocks for automation and they are automated with the help of a software solution. Figure 8.2 shows how an automated P2P process including an embedded claim management process and automated goods receipt system should look like when it is divided into blocks.

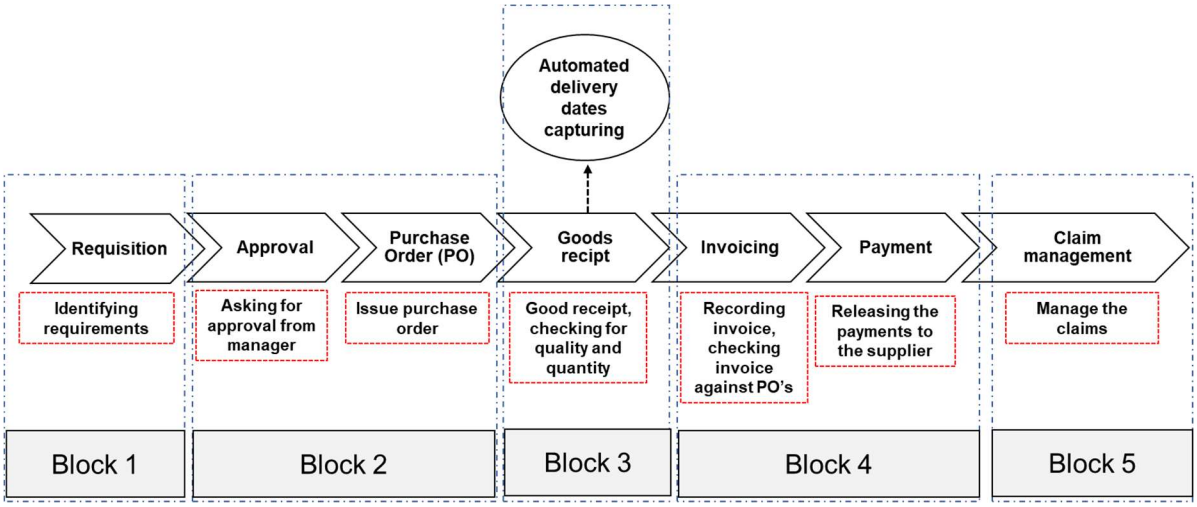


Figure 8.2 Automated "procure to pay" (P2P/R2P) process split in blocks (own content)

The proposed automated solution will result in huge cost savings, mitigate the major risks associated with P2P and will improve the claim capturing at the goods receipt. The details of the process steps are discussed below. The Strategic procurement negotiates and secures contracts with suppliers for any organization. Within these contracts, the SLA's (service level agreements) are negotiated, agreed and set depending on the organizational requirements.

Based on the agreed SLAs penalties are set for the non-performance of suppliers in terms of low quality, late deliveries, noncompliance etc. On-time deliveries of goods are always critical and a top negotiation criterion for any organization. Especially, in the automobile manufacturing industry where all the steps are dependent on each other, delivery of goods are always a top priority and in order to show its importance to supplier, strict penalties are set for non-performance. Further, in most of the big organizations which are not related to the manufacturing industries, the delivery of products is considerably flexible. Therefore, the late deliveries are not followed up properly, mainly due to the non-automated processes used in these organizations. The workers do not capture the information regarding the exact delivery dates of products in their systems timely, resulting in leaving a lot of money on the table.

In the proposed concept the process of delivery dates is automated, it will not only save time but bring more savings and transparency to the business.

8.2 Claim Management in Conventional P2P Process Execution Cycle

In the conventional P2P process, there is no solid base for identifying and capturing the right claims. The process runs in a way that the end users identify their requirements, and the information is sent to the operational procurement department to purchase the desired products. The P2P department receives the requests and takes approvals from their managers and issues a PO to the suppliers. As a next step, the suppliers receive the POs and check the availability of the products. If the product is not available, they contact their internal departments to arrange the products, and if the product is available the supplier arranges the delivery to the customers along with a hard copy of invoice.

The customers receive the products, check them against the POs and inform the procurement department about the arrival of the products. The information of the delivery dates is updated into their internal systems. The procurement department informs the claim department in case of any discrepancy, the claim department receives the information and contacts the suppliers for possible returns, claims, reorders etc. If there are no discrepancies in the orders, the finance department issues the payments, and the P2P process is closed. In the explained manual process there is no definite process to perform the claim management process accurately. The conventional P2P process cycle is executed as shown in figure 8.3.

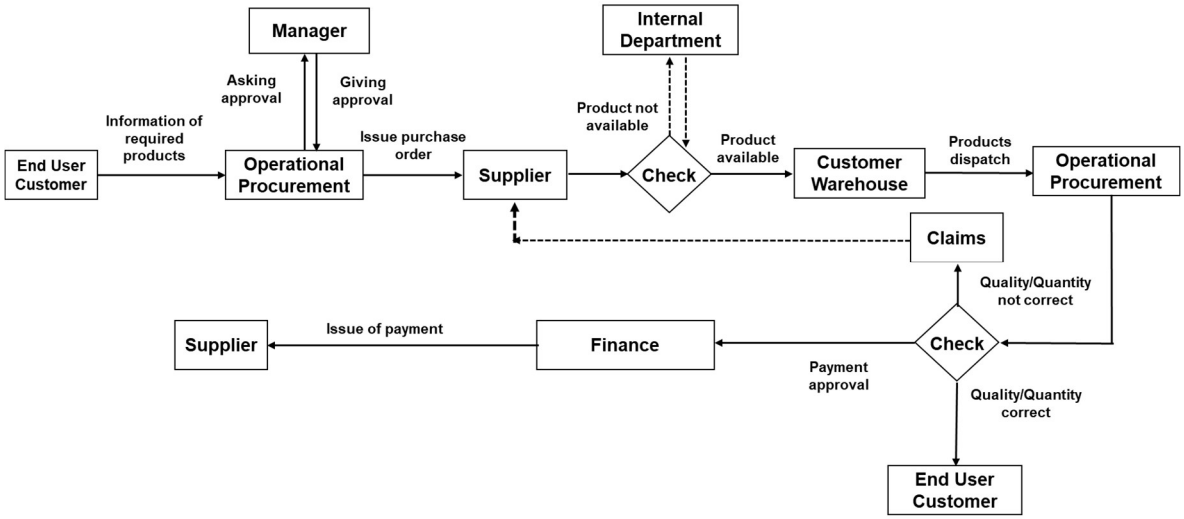


Figure. 8.3 Conventional P2P process execution cycle (own content)

The manual process can work for small businesses, but it is a time-consuming job due to the involvement of many departments in number of repetitive steps which increases the overall effort. The procurement department invests most of their time to perform these tasks, left with no room to think about strategic tasks. But when it comes to mid or big size companies the complexity of processes increases to an uncontrollable level.

8.3 Proposed Automated Claim Management Process

For an automated claim management process, it is a pre-requisite to get the P2P process automated as well. Without the automation of the P2P process, automated claim management cannot be achieved. The proposed automated concept will reduce 40% of the process steps and will lead to tremendous cost savings. Further, the overall transparency of spend and delivery information will also be increased.

In the proposed concept, the main processes are automated, the exchange of all documents across all nodes are electronic, the delivery date capturing are automated (which is the target of the proposed concept), the invoice process is automated, and the payments are electronically executed. An automated P2P process with automated claim management is shown in figure 8.4.

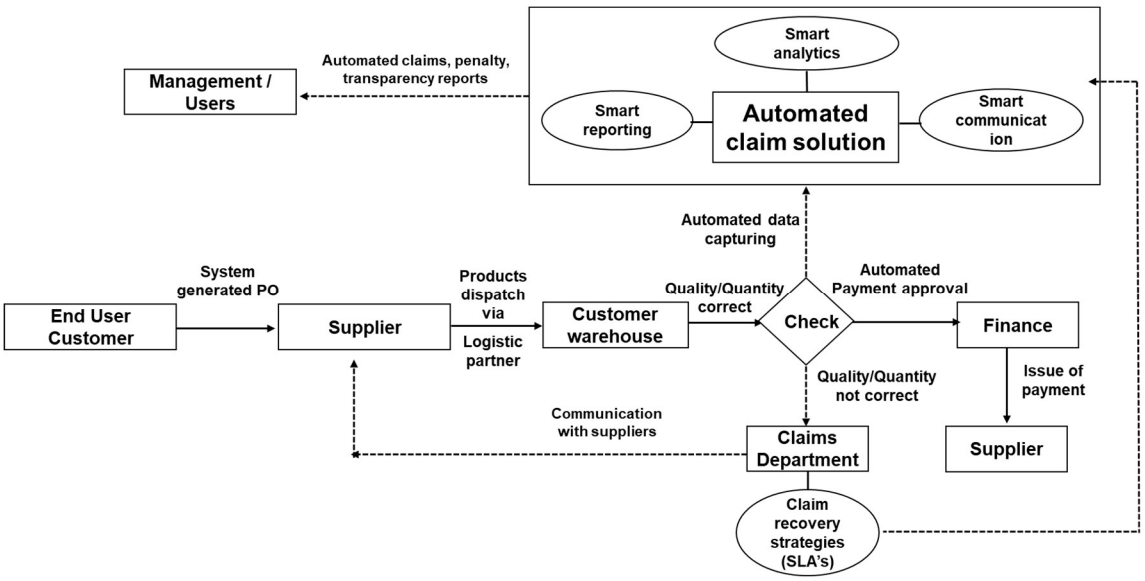


Figure. 8.4 Automated P2P process with claim management concept (own content)

The process starts with providing an access of an automated catalogue system to the end users. The catalogue system is a software-supported system. The end users login into the system with their login details and access a catalogue of all products from all the suppliers with whom contracts are in place. The catalogue will also show other important information like availability of the products, estimated delivery dates, and product price comparisons etc.

The end users order the desired products with an automated system generated PO sent to the supplier. Once the supplier receives the PO, a system automated feedback as “order confirmation” is sent to the end users with the possible dispatch and delivery dates of the products.

In the next phase, the suppliers dispatch the products and an automated email with information of the estimated delivery dates of the products is sent to the end user. The end user can always check the status of the products online as the whole system is automated and fully supports the track and trace facility. Once the products are received at the customer warehouse, the products labels are scanned with RFID devices, the scanning process captures the actual delivery dates of the products and stores them to the database of an automated claim solution running behind the scenes.

If there are any discrepancies regarding the quality and quantity of the product, the information is updated into the automated claim management solution. Once the information is captured, they cannot be changed. As deliveries of products will be taking place on a regular basis, the automated claim management solution will keep storing the information in its database. The automated claim management solution is designed to perform automated analysis, generate smart reporting and is capable of smart communication. By the automation of the process a great visibility will be achieved, the suppliers would not be able to challenge the delivery dates as all the processes are executed in real time.

A set of pre-defined analysis is programmed in the automated claim management solution based on the requirements of the company, these analyses are performed on a regular basis after every entry to the system; smart reports and dashboards are generated in parallel. All

these reports will be communicated to the claim management department on a quarterly basis. These timing can be adjusted to monthly, or weekly basis by the companies depending on their requirements. In case of quality and quantity issues, the information will be communicated to the claim department on the spot. These dashboards will show the performance of suppliers at-a-glance and will bring more visibility to the overall spend and delivery dates.

The claim management department receives the smart reports, and they will not have to invest their time and efforts by analysing the data, as a benefit they will build and communicate strategies for best claim settlement in terms of credit notes, extra rebates etc. On the other hand, the claim management department will also define strategies against the supplier performance, this would lead to supplier development processes. If a supplier is continuously nonperforming the procurement department should think of changing the supplier or of supplier development depending on the importance of the supplier for the organization.

8.4 Benefits of the Proposed Concept

Although there are many benefits of the proposed concept but some of the vital benefits are shown in the figure 8.5.

Figure 8.5. Benefits of proposed claim management solution (own content)

I. Improved Claims Visibility

The main benefit of the proposed concept is to have a better visibility of claims. The business would know where exactly they can get their money back from suppliers for their non-performance. In many big organizations because of non-visibility of claims they leave a lot of money on table, however with the proposed solution this risk will be mitigated. The claim management process has a direct impact on the supplier performances as well, the suppliers know that they are being chased for their non-performance that is how they will put improvement strategies in place.

II. End-User Empowerment

The proposed solution will empower the end user and the P2P department will be skipped for basic supplies. The users will be provided with electronic catalogues, where they can select their required products easily.

III. Improved Spend Visibility

It is often difficult to get the manual processes efficient as well as effective, but by using automated solutions, effective and efficient results can be achieved. The overall cash flow of the organization will be transparent. Once a great level of spend visibility is achieved, doors for improvements and cost savings will be opened.

IV. Reduced Maverick Buying

It has always been a problem for procurement that many workers within an organization buy products without the involvement of procurement. As with the proposed solution the transparency level of spend increases, thus the Maverick Buying could be significantly reduced.

V. Optimized Workflows

With the automated concept, the workflows of procurement are optimized and streamlined, enabling the procurement department to immediately see the approved suppliers, product pricing, and agreed terms & conditions. The automated process will also enable all stakeholders, including suppliers, to view the orders in real time (Freer, 2017). Therefore, this will bring clarity and transparency among the processes, resulting in better cooperation and integration among different departments.

VI. Reduced Costs

The automation concept has a direct impact on the cost savings. Enabling automated process of the operational procurement can make the business to save in millions by reducing Maverick Buying, reduced manual changes, reduced reworks, reduced cash discount losses (myInvenio, 2019). Further, the automated concept gives a real time budget control to keep a track on the funds.

VII. Improved Supplier Management

The proposed concept is dealing with claims, the claims are directly related to suppliers and the supplier management is considered as a strategic and important topic. With the automated solution, the supplier management process will be improved immensely, there would be a clear visibility of the supplier performance. With the automated predefined reports, the strategic procurement can decide strategies to deal with the suppliers.

VIII. Better Decision Making

Another benefit of the proposed solution is that the managers will be able to take right decisions at the right time because the solution provides a great level of transparency. Transparency in any process provides an opportunity for better decision making.

IX. Reduced Claim Settlement Time

Claim settlement in the conventional claim management process is always time consuming because of the involvement of different stakeholders and documentations. The traceability of the records, facts and figures makes the conventional process time consuming. As the proposed solution is automated, all the records, facts and figures are available in real time and involve a high level of transparency, this will automatically reduce communications for clarifications of records, facts and figures, thus claims settlements will be done in minimal time.

X. Reduced Claim Management Cost

The conventional claim management involves different departments of an organization to provide claims related information to the claim management department. The departments require time and effort for providing this information which results in extra costs for the

organization. With the proposed solution the communication for information is reduced due to automation resulting in reduction of the claim management costs.

XI. Electronic Data Interchange

Another benefit of the proposed solution is the implementation of electronic data interchange between the stakeholders. The electronic data interchange increases the transparency level of information and contributes to the overall savings of an organization.

XII. Customer Satisfaction

Customer satisfaction is always considered as a top priority by any business, and with above achievements and benefits of the proposed solution, the overall customer satisfaction level of the business will be increased.

8.5 Practical Implementation Example with Assumptions

In order to give a quick benefit of the proposed concept, it is explained with a simple experiment consisting of some basic assumptions to show how the automated concept improves the claims process and how it provides a solid base for further negotiation with suppliers. In the following example, only the delivery dates have been kept in scope.

Many mid and big size companies issue up to 500,000 POs per year, which includes millions of small products. Let's assume that there is a company "A" which is dealing with 200,000 POs per year, the agreed delivery duration with suppliers in the SLA's is 7 days after the automated PO is received by the supplier from the procurement. A set of penalties in € for late deliveries is also agreed in the SLA's with suppliers which are: 5€ penalty for product delayed for 5 days, 10€ penalty for product delayed for 6-10 days, 15 € penalty for product delayed above 10 days. The report in figure 8.6 is generated for a year divided by quarters.

Once the orders are received at the customer warehouse, the exact delivery dates are captured in the automated claim management solution; the claim solution perform the analysis and sends a report as shown in figure 8.6.

Assumptions	Penalty in €	5.00 €	10.00 €	15.00 €	
	on-time delivery	5 days delay	6-10 days delay	10 days above	Pos per year
Q1	70%	10%	5%	15%	200000
	35000	5000	2500	7500	
					Total
Claim amount in €		25,000.00 €	25,000.00 €	112,500.00 €	**162,500.00 €**
Q2	80%	5%	5%	10%	
	40000	2500	2500	5000	
					Total
Claim amount in €		12,500.00 €	25,000.00 €	75,000.00 €	**112,500.00 €**
Q3	81%	6%	5%	8%	
	40500	3000	2500	4000	
					Total
Claim amount in €		15,000.00 €	25,000.00 €	60,000.00 €	**100,000.00 €**
Q4	88%	5%	5%	2%	
	44000	2500	2500	1000	
					Total
Claim amount in €		12,500.00 €	25,000.00 €	15,000.00 €	**52,500.00 €**
Yearly Claim amount in €	**427,500.00 €**				

Figure. 8.6 Sample results of the yearly claims (own content)

The report gives clear information about the yearly claim amount in € against the supplier, it also shows the performance of the supplier in terms of delivery per quarter. Once the claim departments have such a report of the real-time information in hands, they can make strategies to hold the supplier responsible and get their money back.

8.6 Limitations of the Proposed Solution

The proposed automated claim management process brings many benefits for the organizations, but there are some limitations associated with the proposed concept

a) Dependency on P2P:

The proposed concept is not a standalone solution, rather it is dependent on an automated P2P process, and this process cannot be implemented unless an automated P2P process is in place, therefore the limitations in the automated P2P process are the limitation of this concept as well.

b) High Implementation Costs:

As the proposed concept is directly related to the automation of the P2P process, so the implementation costs will be comparatively higher than other processes.

c) Data Dependency:

Data is power, the proposed concept is fully dependent on the input data from automated P2P process to create claim management base, if the input data consists of errors or bugs, it will have an impact on the overall results.

8.7 Chapter Conclusion

Poor claim management processes have always been problematic for many organizations. Claim management is an integral part of the procurement processes and procurement is considered as one of the most important part of supply chain management. If the procurement processes are correctly executed, the whole supply chain will be automatically improved which would produce better results in terms of cost savings and customer satisfaction.

The world is already progressing into the digitization and most of the industries are moving forward with a constant pace toward digitization. For accurate and improved claim management process it is important to get the P2P process automated, as this is a prerequisite to improved claim management processes. P2P is the operational part of procurement where actual purchasing is executed within this process, so if the P2P is not achieving its goals, the overall procurement will get affected.

The P2P automation will provide a solid base for an automated claim management process implementation. All the delivery dates, product conditions will be captured in the system in real-time, which will increase the overall transparency of spend and result in great benefits for the organization. As claims are dependent on transparent information, so the spend transparency will improve the overall claim management process.

Chapter 9: Automation Concept for Supplier Management

Supplier management is considered an integral part of the strategic procurement process, it is the process to manage your suppliers properly and to achieve maximum value for your organization. An integrated and strategically focused supplier management can fix vulnerabilities and weak points in dealing with suppliers. Many companies are not aware of the deficits in their supplier Management. Figure 9.1 shows companies with no supplier management and a proper supplier management.

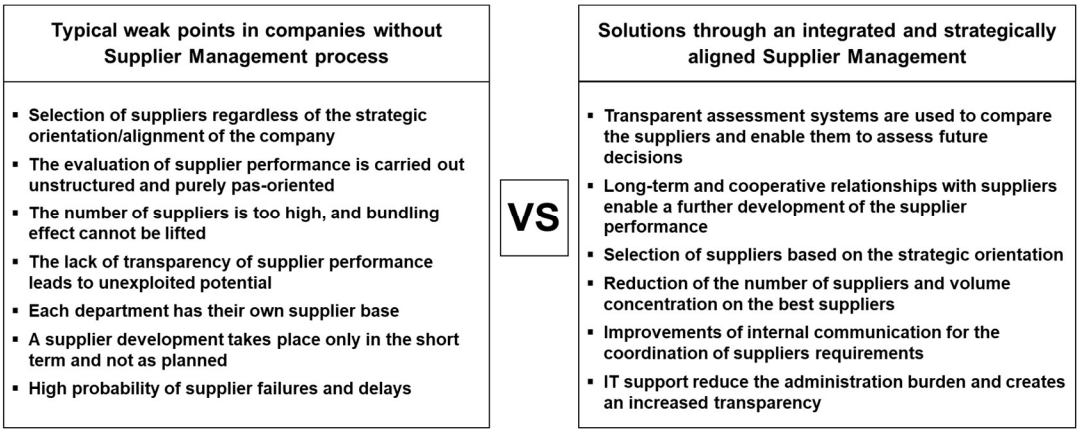


Figure 9.1. No supplier management vs. proper supplier management (own content)

Today's complexity in procurement poses increased requirements for collaboration with suppliers. If customers' needs become more sophisticated and volatile, more and more components are purchased, and supply chains are to be considered globally through globalization. A functioning supplier management is the basis to meet these challenges. With modern supplier management, you face challenges such as reduction of value creation and globalization. Cooperation with the right suppliers creates sustainable competitive advantages and benefit with a controlled risk. Below figure shows some of the challenges faced in the supplier management process on a high level.

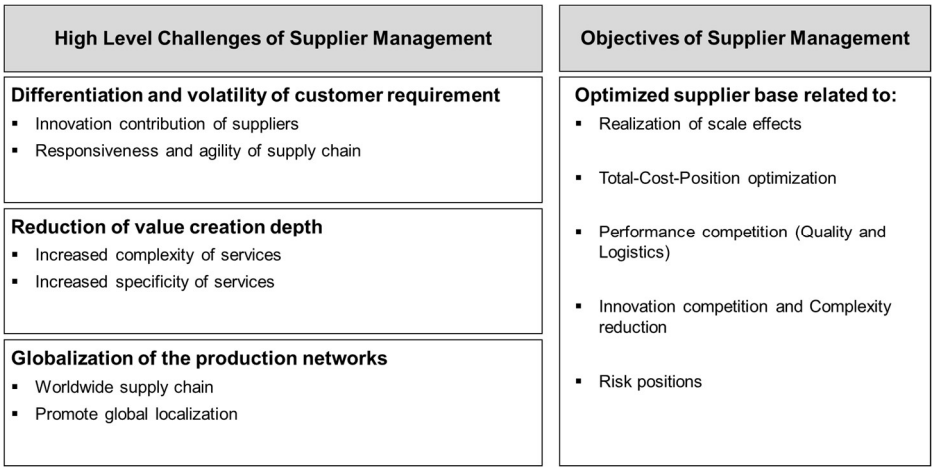


Figure 9.2. High-level challenges of modern supplier management (own content)

Because of the challenging nature of the modern supplier management, the important point to be mentioned here is, that the supplier management is not a one-off process; rather it is the process of continuous improvements. Below figure shows how this continuous improvement process should work.

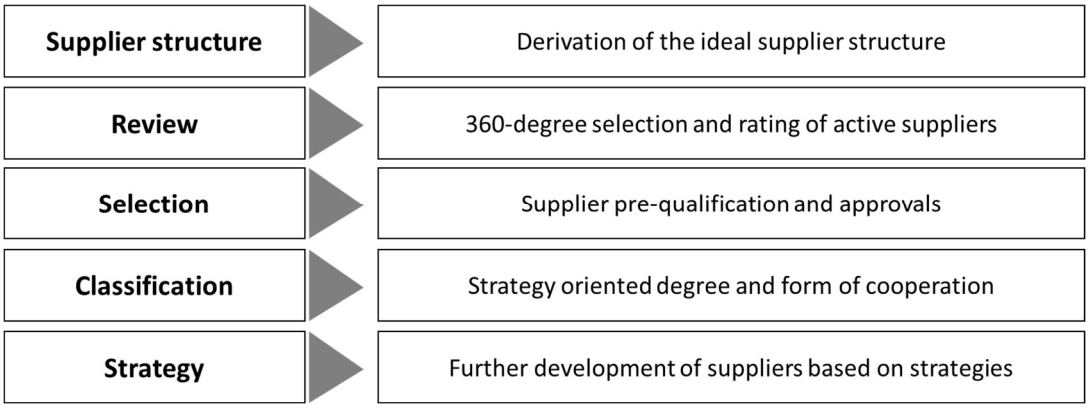


Figure 9.3. Continuous improvement process for supplier management (own content)

9.1 Supplier Relationship Management Process

Supplier relationship management process (SRM) describes how companies deal with different suppliers to meet their business goals and acquire the necessary goods and services. Therefore, it is of vital importance to find ways to manage the interactions between companies and suppliers in order to maximize value.

Many researchers have explained the SRM process in different ways. (Beil, 2011) & (Teller, 2016) have addressed, SRM as the process of differentiation, in which various suppliers are evaluated and prioritized according to the value they create for the company that acquires their goods and services. The more valuable a supplier, the more important the interaction with the supplier. The overall goal of SRM is to maximize the value of interactions between companies and suppliers to maximize the value of those interactions. It is used to form closer relationships and, in the end, achieve better conditions and prices. Suppliers must meet certain criteria to be assessed accordingly.

Organizations must screen their list of potential suppliers for assets and capabilities, and based on their internal business strategy, prioritize the interactions with the suppliers. The process of SRM entails things like negotiating contracts, purchasing, managing logistics and delivery, or collaborating on product design. To get the most out of all these areas, there needs to be holistic strategy in place in order to communicate a single, and united message to the suppliers. This strategy needs to fit in with the overall business strategy of the company, and every administrative level of the company needs to work in accordance to the strategy. Good SRM in that regard just works like good marketing or an efficient customer relationship management.

9.2 Sourcing Strategies

Before identifying, the type of relationship to be established with a supplier, it is necessary to identify and select a sourcing strategy that allows organizations to select their suppliers and the right number of suppliers they are ready to work with. Identification of the sourcing may be

different in different organizations, but one has to know, how different is one's strategy to the supplier structure? One should think about the ideal composition of one's supplier base for each procurement market or material group

- Does one define the ideal composition of the supplier base for each procurement market (=material group)?
- Does one analyse the need for cooperation and partnership for each procurement market and determine a partnership strategy?
- Does one analyse the ideal local composition of the supplier base for each procurement market?
- Does one determine the ideal supplier number for each procurement market?
- Does one analyse the critical suppliers and their markets?

The development of the supplier sourcing strategy is the basis for a successful supplier management. The supplier sourcing strategy defines the ideal composition of the supplier base. It is important for a manufacturing company to know how many suppliers it needs for the sourcing of raw materials or components. Choosing the right supplier is crucial, because generally raw materials and components represent more than 50 % of the goods sold to a company.

Choosing the right number of suppliers is key to the success for any organization, there are two main strategies to identify the right number of suppliers for any business shown in figure 9.4.

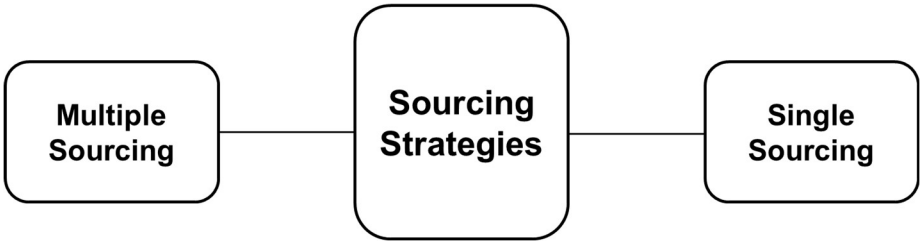


Figure 9.4. Sourcing strategies, figure based on (O'Byrne, 2019) *with modifications*

9.2.1 Multiple Sourcing

The selection of the right sourcing strategy depends on the company's own requirements. Multiple sourcing means when companies buy their products from more than one supplier. Companies use multiple sourcing to get the lowest price for a product, because it includes competition among the suppliers.

9.2.2 Single Sourcing

Single sourcing means when companies buy their products from one supplier. Some companies use single sourcing strategy, which means choosing one supplier for the business that contributes to a strong relationship between the company and its supplier's partnership

Both these strategies have their own advantages and disadvantages presented in Table 9.1 on the next page.

	Single Sourcing	Multiple Sourcing
Product quality	Cooperation, focus on quality	Standard products
Delivery variation	Low	High risk
Risk of supply distribution	High risk	Low
Partnership relation	A precondition	Unlikely
Collaborative product development	A possibility	Unlikely
Price	High	Low
Costs for supplier relations	Possibly lower	Probably high

Table 9.1: Advantages and disadvantages of both single and multiple sourcing (own content)

A mix of both these strategies is also a common practice in the industry and is referred to as hybrid sourcing. In this case, the company has a preferred supplier, and the others are back up so the sourcing will be more secure (Beil, 2011).

9.3 Risks Associated with Suppliers

Supply risks are the risks directly associated with suppliers and are the most common risks to any supply chain and it is one of the most important risks to be dealt with. These risks should be timely and properly identified, and should be mitigated at the earliest because, this risk mainly occurs at the supplier side in the procurement phase of supply chain.

Supply risk is resulted by any interruptions to the flow of product; the flow could be of raw materials or parts within a supply chain (Queenland, 2013). If supply to any production process is disrupted, apparently, the production operations will be disturbed, and all the following elements of the supply chain will be affected.

According to (Lall, 2011) a supply risk can also be defined as "the possibility of disruptions of product availability from the supplier or disruptions in the process of transportation from the supplier to the customer".

A supplier may not be able to complete an order due to several reasons. These reasons could be, problems with sourcing of necessary raw materials, equipment failure, damaged facilities, or any other unlikely disruption. The products in-transit can face transportation disruptions and

are added to the delivery lead-time. The transportation disruptions may be caused, by delays in customs clearance at borders, traffic conjunctions or problems with the mode of transportation. In order to overcome the supply risks, one of the most important point is to select the right suppliers for the business because most supply risks are associated with the suppliers. Choosing the correct suppliers can help to mitigate many of the supply risks.

9.4 Supplier Evaluation Categories or Supplier Selection Criteria

Supplier evaluation categories are the ones through which the suppliers are evaluated and in order to proceed further into the details of the supplier selection process, it is important to identify the key supplier evaluation categories (Bello, 2003).

The supplier selection is based on the ability of a supplier to deliver its services in terms of quality, quantity, cost, and delivery time (Employment, 2011). It is important for the procurement department to identify that which performance categories should be included in the supplier selection process. In most cases, the prime focus of many organizations is on criteria i.e., **cost, quality and delivery time** and these criteria are the most critical ones, which have a direct impact on procurement.

In most cases, these three performance indicators are enough for the supplier selection process, but for critical items it is important to have a deep analysis of the supplier's capabilities and the supplier evaluation should be performed in a much-detailed way.

Below are some criteria presented by (Bello, 2003) for the detailed supplier selection and they are considered as supplier selection criteria, but they are not all. Organizations have to define these criteria based on their preferences and priorities. The bottom line is to select the best of the best available and it could be the possible best supplier selection criteria for any business.

- Cost
- Quality
- Delivery time
- Supplier's management capability
- Staff capabilities
- Cost structure of the supplier
- Availability of required infra structure, facilities
- Process and technological capabilities
- Environmental regulation compliance
- Financial capability and stability
- Information systems capabilities
- Long-term relationship commitment
- ISO 9001: 2008 certification (if required)

Further to the above, in general, one has to know answers to below questions for the supplier evaluation process.

- Do you assess all the key performance aspects (hard and soft facts) from all significant suppliers?

- Do you also assess the future performance of your suppliers – including their risks?
- Do you assess your suppliers together with the cross-functional partners, for example, in logistics, quality and development?
- Are the supplier evaluation results, discussed in detail with the supplier and are consequences drawn?
- Is the supplier evaluation considered in the award decision?

9.5 Supplier Selection Process

Supplier selection process is the most important part for the supplier management process; it is the process where you select the suppliers for your business. In today's world of highly competitive environment, an effective supplier selection process is extremely essential; this could lead to the success of an organization. Supplier selection is the process of identifying, evaluating, and making contracts with suppliers. Typical high-level steps involved in the supplier selection process are, identifying potential suppliers, gathering information, setting contract terms, negotiations, and evaluation of suppliers. The supplier selection process requires a great number of financial resources of an organization.

Simply, looking for suppliers with lowest prices is not an efficient sourcing strategy anymore; rather the decision of selecting a supplier should be performed with multiple criteria. Choosing the right supplier and the right number of suppliers for the business is important. In today's world of global competence, the firms try to choose the best suppliers for their business but at the same time they do not stick to only a single supplier and there are reasons behind it.

The supplier selection process is one of the most important element of supply chain management process. Many researchers are taking interest in this area and are providing different findings to improve the process of supplier selection, the supplier selection problem has received considerable attention in academic research and literature (Lung, 2007). Some of the research works of different authors are presented here.

In the increasing competitive business world of today, the supplier's selection and evaluation process is considered as one of the most critical activities for a company, a strategic purchasing decision that commit significant resources (40% to 80% of total product cost) and impact the total performance of the firm (Aguezzoul, 2004).

For the success of any manufacturing organization, an effective supplier selection process is very important, the prime goal of the supplier selection process is to reduce risk in procurement and to maximize the overall performance and to develop a long-term relationship between the procurement and the supplier (Ompal, 2013).

A correct and sound supplier selection decision today can reduce the losses and problems of tomorrow (Thomson, 2005).

The success of any supply chain is mostly dependent on selection of good suppliers. Simply looking for suppliers offering the lowest prices is not considered as 'efficient sourcing' anymore. Multiple criteria need to be considered when selecting a supplier (Lung, 2007).

In early 1960s (Dickson, 1966) presented 23 criteria that must be considered by procurement in evaluating suppliers. A later review in 1991 (Weber, 1991) stated that over half of 74 annotated and classified research papers which were reviewed by a team, addressed the

supplier selection with multiple criteria since 1966. A proper attention was given to the criteria and analytical methods were used in the vendor selection process.

Another study by (Luitzen, 2001) presented a framework for supplier selection. This framework covers the different phases involved in the supplier selection process including pre-qualification, formulation of criteria, and final evaluation etc. Further to above, according to (Simpson, 2002) most common and important issues in the supplier selection process consists of:

- The issues with physical distribution (accurate order processing and on time deliveries)
- Management issues (quality commitment and further improvements),
- Pricing issues (providing competitive pricing)
- Relationship issues (customer service, timely and accurate responsiveness, ethical values, professional communication, trustworthy relationships)
- Quality issues (quality management, outgoing quality control)

Addressing these issues and all other selection criteria in the supplier selection process provides a great chance of choosing the right supplier for the business. The prime goal of the supplier selection process, in such details is to select the best supplier out of the available.

9.5.1 Conventional Steps in Supplier Selection Process

In today's world of global competence almost all the large organizations and manufacturers spend roughly half of their revenue to purchase goods and services (Beil, 2009), due to increasing reliance on outsourcing many of the complex services and products.

This makes the success of the firms more dependent on their relationships and interactions with the suppliers; making the role of the procurement department of the firms more challenging that involves a lot of money. The supplier selection process is the process through which the companies/buyers/procurement identify, evaluate, and hire the best possible suppliers out of the available. The supplier selection process requires a great amount of financial resources of the purchaser, and in return, the procurement expect significant benefits from the selected suppliers (Beil, 2009).

The supplier selection and evaluation process can be performed in the following steps (Beil, 2009), (Monczka, 2005).

i. Recognize Need for Supplier Selection

The first and most important step is to identify when a new supplier is needed? It means that a purchaser or firm should know when there is a need to hire a new supplier.

ii. Identifying Potential Suppliers

In order to survive in the fast-changing markets and to move along with the competitive global economy, it is often very important to not only develop the existing suppliers but also search for new suppliers and discover the best suppliers, which suit the business. The firms or procurement should identify the suppliers, which have a potential of serving them.

iii. Importance of New Suppliers

There are several factors, which make new suppliers important. There may be a possibility of existence of new suppliers which are superior in some ways to the existing suppliers of the firm. For example, a new supplier may be providing their services in a reduced cost and high quality because of their development of a new production technology which allows cost saving processes, or a new supplier may have short lead-times as compared to the existing suppliers or the purchaser may need additional suppliers to create an environment for competition in terms of cost, quality, and lead-time.

iv. Supplier Pre-qualification Screening Process

Discovering and selecting a new supplier in the first place is quite challenging because it is important to verify that the new supplier has the ability and capability to meet the requirements of procurement. The non-performance of the new supplier on a very basic level and for the simplest items can bring disastrous consequences for the organization (Beil, 2009), making the supplier qualification-screening process more important.

In recent times as explained in chapter 1, there have been many incidents where the production processes of big companies have been affected because of the non-performance of their suppliers.

In the daily consumer products, safety issues with many products have been traced back to the supplier failing to meet the procurement requirements, causing serious and dangerous consequences. The non-performance of the suppliers puts the reputation of the manufacturers on stake, which is not desired by any organization. Delays in the production processes due to the shortage or unavailability of items and recalls of faulty products produced by the noncompliant suppliers, have costed the procurement millions of dollars in warranty costs, recalls, inventory adjustments etc. and above all, these have caused a vital damage to the reputation of organizations.

In order to avoid the unexpected outcomes from the non-performance of the supplier, the procurement should initiate proactive measures to verify a supplier through the qualification process prior to awarding the contract to the supplier. The main goal of the "supplier qualification screening" is to reduce the chances of the non-performance of the supplier.

A secondary aim is to strengthen the relationship between the supplier and the procurement. It is to be made sure that the supplier is more responsible and trustworthy partner in business with the procurement. **A detailed supplier prequalification template is shown in Supplier PQQ Tempate-ANNEX1**

v. Creating a Supply Base

During this phase of the supplier selection process, the suppliers who pass the qualification process and are eligible for the contract to be awarded, are normally referred as "pre-qualified" suppliers. All the pre-qualified suppliers are added to a long list known as supply base. If the procurement wants to use the suppliers for similar items, it makes sense to make a group of pre-qualified suppliers who will compete among themselves for the contracts. A pre-qualified supply base can be used for short term as well as long term contracts, if there are similar items needed by the procurement. In other case if the pre-qualified suppliers have the capability of

producing different items, they can compete to produce those products whose long-term contract is up for rebidding.

vi. Information Requests to Suppliers

Once the potential suppliers are identified, the next phase in the supplier selection process is to request the suppliers to provide information about their services or goods. Although there is no agreed terminology for the information requests, but generally the procurement uses one of the three types of information requests to suppliers. The request types which are sent to suppliers are described below, each of them is appropriate for a different situation (Bizmocom, 2011).

- Request for Information (RFI)
- Request for Proposal (RFP)
- Request for Quote (RFQ)

vii. Contract Terms

The supplier selection process results in a contract between procurement and one or more suppliers. All the information, which have been gathered from different suppliers through the information gathering, and request processes, must be translated into formal legal contractual terms before the contracts take place (Beil, 2009).

A contract specifies the terms, what the supplier would provide to the procurement and how the procurement would pay the supplier for the services or goods. The contracts can specify payment and non-payment arrangements, and the contract terms relate to either the payment terms or how the contracts will be executed i.e., the non-payment terms. These terms of the contract should be mutually agreed between procurement and the supplier before the contract is signed but it is important for both the parties to have a clear understanding on each term of the contract and after the contract is signed, the contract should be honoured.

viii. Negotiation Process

"Every time when you negotiate, you have to make choices that affect whether you achieve a successful outcome for your business. To get the best outcomes, you need to understand the steps involved in the negotiation process" (Queenland, 2014). While making a decision about the award of the contract, the procurement normally considers the supplier qualification and the contract terms to be agreed.

The reputation of a supplier can be based on a long-term historical data. For choosing a new supplier, the negotiation process becomes more important. All the contract terms can be negotiable between the supplier and the procurement. The negotiation process brings the suppliers and procurement on the same page, binding them in a mutually agreed and acceptable relationship, which in most cases is long lasting.

In the negotiation process the procurement tries to present favourable terms of the procurement, likewise the supplier tries to present favourable terms of the supplier. There are different types of negotiation processes from the procurement as well as supplier’s point of view.

ix. Supplier Evaluation and Contract Award

This section shows that how a supplier is evaluated by the procurement, how the winner of the contract is determined and how the follow up monitoring is performed for the future supplier selections. In the supplier evaluation process the suppliers are ranked in an order by the procurement, and these ranks are used along with other business considerations to determine to which supplier the contract should be awarded. Finally, after contract is awarded the procurement can monitor the performance of the supplier.

All the above points discussed in section are part of tactical and strategic procurement.

9.6 Methodology

The research in this chapter is divided into 2 sections below.

1. **Section (9.6.1) Possible Automated Supplier Selection Process:**

In this section, a concept is presented which could be beneficial for future researchers which could automate the supplier selection process with the help of Monte Carlo simulation. I have tried to explain on a high level how this process should work, but the future researchers should deep dive in this area to explore it more.

The concept shows how the supplier selection process possibility could be automated. The objective of the section is to find an effective concept, which would effectively manage the risks associated with supplier selection process. To achieve the objective, certain approaches and methods have been used to sustain supply chain process with maximum efficiency and accuracy.

2. **Section (9.6.2) Supplier Evaluation Process Connected with the Automated Spend Management Concept**

This section shows an automated supplier evaluation process that could work with the outcome of the automated spend management concept explained in chapter7. This concept is only applicable for the existing suppliers of a business. As this research is focused, to automate the overall procurement processes, so I have tried to connect all the processes with one another to achieve one-solution and maximum results.

9.6.1 Possible Automated Supplier Selection Process.

Different researchers have proposed different methods for the risk management in the supplier selection problem. One of them is the "Weighted Point Method". In order to achieve further improvements and efficient results in this research, the “Weighted Point Method” is embedded with Monte Carlo simulation to analyse the supplier selection problem.

For risk analysis, different authors have presented different types of risk analysis techniques in their projects. (Nurmaya, 2012) has presented the co-citation analysis approach in his research work and many other authors have used other techniques but in this research the Monte Carlo Simulation is used to analyse the risks of the Supply Chain.

To implement the proposed concept with the help of an experiment, a scenario has been created, where a long list of suppliers has been taken into consideration and the best supplier amongst all has been selected based on the selection criteria through the Monte Carlo simulation. The objective addressed in this section is to analyse how the risks associated with

supplier selection process can be mitigated. This method could be beneficial for future researchers to use Monte Carlo simulation embedded with Weighted Point Method in the supplier selection process.

9.6.1.1 Weighted Point Method

There are several methods recommended by many researchers for supplier evaluation and selection problem. Every method used for the supplier evaluation and selection process has a great importance and can have a significant influence on the selection results (Tahriri, 2008). One of most common and popular method is the “Weight-Point Method”. Weight-point method is one of the most frequently used methods for supplier evaluation process, with this method the suppliers are weighted on different criteria and attributes, which have priorities and importance for the business (Goh, 2018). Based on certain attributes and performance criteria, the evaluation team assigns a weightage and score to each supplier. These performance criteria differ from business to business.

The scores obtained, are then multiplied with the assigned weights and a final evaluation score of the supplier is achieved. In order to perform the supplier evaluation task in this research, I have used the Weighted Point Method with some changes and improvements in two different ways for the supplier evaluation.

Although, it is a simple method and can fit into any organization, but it is extremely important to use it in a correct way. The supplier relationship managers must use this method with the important criteria in mind. They should wisely select the criteria and parameters, which fit their organizational needs perfectly and should have a high priority within the organization in order to achieve best results.

Every organization has its own priority parameters, but in this research, I have mentioned the parameters, which could apply to any type of organization. An alternative solution, which is presented in the chapter section (9.6.2.), is designed in such a way, where the user can change the criteria and their weightage according to their requirement and they will get an automated supplier evaluation.

9.6.1.2 Monte Carlo Simulation Overview

Monte Carlo simulation is a computerized mathematical technique that allows firms and users to account risk in quantitative analysis and decision-making. This technique is used by professionals in wide range of fields as finance, project management, energy, manufacturing, engineering, research and development, insurance, oil & gas and transportation (Palisade, 2013). Monte Carlo simulation is also called probability simulation and it is used to understand the impact of risk and uncertainty in finance, project management, spend analysis and forcasting models.

Monte Carlo simulation is a technique that takes the distributions which have been specified on the inputs to the model and uses them to produce a probability distribution of the output of interest. It executes by running through the sequence of actions as many times as the user specifies (Rodger, 1999).

The Monte Carlo method is distinguished from other techniques in numerical analysis by the use of random sampling to construct the solution of a physical or mathematical problem (Cashwell, 1975).

"Monte Carlo simulation provides a range of possible outcomes and the probabilities of occurrence for any choice of action for a decision maker. It provides extreme possibilities, the outcomes of going for broke and for the most conservative decision along with all possible consequences for middle of the road decisions" (Rodger, 1999).

Monte Carlo simulation works in a very simple way. On every iteration and for each input, the Monte Carlo simulator selects a random value from the probability distribution, which is relevant and is used in the input, in a way over many iterations. The distribution of the selected values shows the input probability distribution. Monte Carlo simulation gives us a possibility to see all the possible outcomes of our decisions and shows the possible impact of risk. This allows us to make better decisions under uncertainties and ambiguities.

9.6.1.3 Proposed Solution

As the supplier evaluation and selection process requires a great amount of effort in terms of money and time for the procurement, that is why the supplier selection process should be performed in an effective way to select the best and accurate supplier as per the requirement of the procurement. While selecting a new supplier, procurement keeps the 3 most important selection criteria or parameters in their calculation.

- Price
- Lead time
- Quality

Although these parameters are most important but, in some cases, these 3 parameters are not enough for the selection of a supplier. Many more parameters should be included in the calculation to observe a better result. In this section, an experiment is performed for the supplier selection with Monte Carlo simulation where additional selection parameters are taken into consideration. A certain weight is given to every parameter as per the importance of each parameter which has been explained by researchers.

Price, Quality and Delivery time have got maximum of the weight because many researchers including a research by (Thanaraksakul, 2009) shows that most of the organizations, select their suppliers based on these 3 parameters. The aim is to include as many as possible parameters into the experiment in order to take a good advantage from the Monte Carlo simulation in the supplier selection process and to identify the best suppliers with maximum parameters to achieve good result.

The parameters are weighted with the relative importance considered by the procurement as 0 (less important) to 1 (most important). The weight for each parameter is multiplied by the performance score assigned. In the end, all these individual scores are combined, and a final score is achieved for each supplier (Bello, 2003). Based on the final score the best supplier out of the available is discovered.

9.6.1.4 Supplier Selection with Monte Carlo Simulation Experiment

Let’s assume a company named as ABC, the company is looking for new suppliers. There are 5 different suppliers available in the market which have already qualified all the important pre-selection steps to bid to the company ABC. The company ABC has set following 15 parameters, which are used to evaluate the supplier. These parameters are weighted with the

relative importance considered by the company ABC on a scale of 0 (less important) to 1(most important) as shown in table 9.2. The suppliers are considered as (Supplier1, Supplier2, Supplier3, Supplier4 and Supplier5) and evaluation parameters are:

- Cost
- Quality
- Delivery time
- Supplier management capabilities
- Supplier non-management staff capabilities
- Ability to meet company requirements
- Cost structure of the supplier
- Financial capabilities
- Supplier infrastructure / facilities
- Process and Technological capabilities
- Environmental regulation compliance
- Information System capabilities
- Long term relationships potential
- Reliability
- ISO 9001:2008

Table 9.2 shows the matrix with weighted attributes as required by the Company ABC. It means that the Buyer in company ABC has set the parameters with weights 0 (less important) to 1(most important) as its requirement. The company ABC is looking for the suppliers, which can offer their services based on parameters as shown in the table 9.2 and will select the supplier whose score is maximum. This information is shared with all the suppliers for their feedback.

Parameter	Weights	Supplier1	Supplier2	Supplier3	Supplier4	Supplier5
Cost	0.9					
Quality	0.8					
Delivery time	0.7					
Supplier management capabilities	0.4					
Supplier non management staff capabilities	0.2					
Ability to meet company requirements	0.6					
Cost structure of the supplier	0.2					
Financial capabilities	0.35					
Supplier infrastructure / facilities	0.3					
Process and Technological capabilities	0.1					
Environmental regulation compliance	0.45					
Information System capabilities	0.2					
Long term relationships potential	0.3					
Reliability	0.6					
ISO 9001:2008	0.3					

Table 9.2. WPM example: matrix with weight attributes "buyer requirements" (own content)

In the next step, as a feedback, all the 5 suppliers in scope have weighted all the parameters as per their own capabilities, which are shown in table 9.3. The table shows the parameters along with the weights received back from the suppliers.

Parameter	Weights	Supplier1	Supplier2	Supplier3	Supplier4	Supplier5
Cost	0.9	0.7	0.8	0.8	0.6	0.5
Quality	0.8	0.6	0.6	0.65	0.6	0.7
Delivery time	0.7	0.75	0.6	0.6	0.7	0.65
Supplier management capabilities	0.4	0.6	0.4	0.6	0.2	0.35
Supplier non management staff capabilities	0.2	0.75	0.2	0.3	0.4	0.75
Ability to meet company requirements	0.6	0.45	0.55	0.45	0.6	0.55
Cost structure of the supplier	0.2	0.6	0.35	0.2	0.5	0.6
Financial capabilities	0.35	0.65	0.45	0.35	0.75	0.25
Supplier infrastructure / facilities	0.3	0.3	0.3	0.35	0.35	0.31
Process and Technological capabilities	0.1	0.2	0.25	0.15	0.2	0.25
Environmental regulation compliance	0.45	0.3	0.4	0.35	0.2	0.6
Information System capabilities	0.2	0.25	0.4	0.4	0.5	0.45
Long term relationships potential	0.3	0.6	0.55	0.5	0.35	0.2
Reliability	0.6	0.6	0.5	0.35	0.6	0.65
ISO 9001:2008	0.3	0.55	0.15	0.25	0.35	0.45

Table 9.3. WPM example: matrix with weight attributes “supplier offer" (own content)

In the next step, the final score of each supplier is obtained using the formula of Weighted Point Method. The final score shows the best supplier among all the 5 suppliers, which is shown in table 9.4. Based on the final score, Supplier1 has got the maximum score and is considered the best supplier out of 5 available suppliers. Until now, Monte Carlo simulation has not been used, at this stage the weighted values from the suppliers are constant values, but while doing the experiment with Monte Carlo simulation, probability distribution will be used at each cell, that is explained later.

The formula1 below is used to get the final scores, the same formula is used when the experiment is performed through the Monte Carlo simulation.

Formula1

Supplier1=(0.9x0.7)+(0.8x0.6)+(0.7x0.75)+(0.4x0.6)+(0.2x0.75)+(0.6x0.45)+(0.2x0.6)+(0.35x0.65)+(0.3x0.3)+(0.1x0.2)+(0.45x0.3)+(0.2x0.25)+(0.3x0.6)+(0.6x0.6)+(0.3x0.55)= 3.6425

The same formula is used to obtain the scores for all the other remaining suppliers.

	Final Scores	
	Supplier No	Score
1	Supplier1	3.6425
2	Supplier5	3.3555
3	Supplier4	3.2775
4	Supplier2	3.2625
5	Supplier3	3.185

Table 9.4. WMP example final scores without Monte Carlo simulation (own content)

Table 9.4. shows the detailed scores of all suppliers. The supplier which has got the best score is Supplier1 and is the winner. The supplier which has got the 2nd high score is Supplier5, thus

it is considered as the 2nd best supplier among the available. The remaining order of the suppliers based on their achieved scores is Supplier4, Supplier2, and Supplier3.

In the next phase of the experiment, it is shown that how all the suppliers are rated when Monte Carlo simulation calculates the values and which supplier gets the best score, which supplier makes 2nd position in the table and so on. Table 9.5 shows the values when a probability distribution is used in the input weights from the supplier's offer and based on those values a comparison has been made.

WPM Example: Matrix with weight attributes " Supplier Offer with Probability Distribution using Monte Carlo"						
Parameter	Weights	Supplier1	Supplier2	Supplier3	Supplier4	Supplier5
Cost	0.9	0.7311401	0.814624	0.80063775	0.60756014	0.509376067
Quality	0.8	0.5455146	0.6481586	0.66665244	0.47916264	0.636844108
Delivery time	0.7	0.7226967	0.6672504	0.58332504	0.67674104	0.700236833
Supplier management capabilities	0.4	0.5691097	0.4921343	0.60475003	0.17198271	0.473795774
Supplier non management staff capabilities	0.2	0.7570958	0.1931465	0.36439649	0.36600387	0.71260168
Ability to meet company requirements	0.6	0.4414848	0.5184574	0.46004101	0.61575503	0.540209802
Cost structure of the supplier	0.2	0.5781908	0.352414	0.21652358	0.49685426	0.588725804
Financial capabilities	0.35	0.6597249	0.4420041	0.35362768	0.73144096	0.211015323
Supplier infrastructure / facilities	0.3	0.354504	0.3392747	0.35401832	0.30604206	0.317232442
Process and Technological capabilities	0.1	0.2362806	0.1794006	0.18848173	0.20583061	0.240213882
Environmental regulation compliance	0.45	0.2577698	0.3830631	0.33423222	0.21541422	0.592568415
Information System capabilities	0.2	0.2532905	0.2967656	0.41545019	0.46056673	0.36512046
Long term relationships potential	0.3	0.3642836	0.5347022	0.49585815	0.35208056	0.182756726
Reliability	0.6	0.6262219	0.4554079	0.35057474	0.59728692	0.650244848
ISO 9001:2008	0.3	0.540823	0.1837057	0.25364684	0.38572269	0.470730072

Table 9.5. WPM example: matrix with weight attributes "supplier offer with probability distribution using Monte Carlo simulation" (own content)

A triangular distribution is used for each cell associated. The reason to use a triangular distribution is that there is possibility of putting lower, most likely and upper bound of the values. So, for every cell an upper, lower, and most likely bound is defined, keeping the most likely value as of table 9.2. The reason of using a probability distribution is, all the values are uncertain and to get best possible solution from the uncertain values can be an achievement. When a simulation is run with the upper, lower, and most likely values, the above values shown in table 9.5 are obtained.

In the next steps all these values including the triangular distribution are used in the formula of WPM and simulated for 10.000 times, table 9.6 shows the details. The tool used for Monte Carlo simulation in this experiment is a software called "Risk Solver Platform". This software is a powerful tool and works extremely fast and provides a lot of information including graphs, charts, and statistics in a single window screen (Solver, 2014).

The results in table 9.7 shows final scores, still Supplier1 has the maximum score and is considered as the best supplier. The final scores presented in table 9.7 are much more accurate as it shows the values obtained from uncertain information and are captured in the result of 10.000 different random values. This makes the Monte Carlo simulation a much more powerful tool to analyse every kind of uncertain situation and provide the best possible solution.

Further another built formula has been used to calculate the mean value of score, when the simulation is run for 10.000 times, the mean function stores the values of all these 10.000 times and provides the mean of all the values.

Parameter	Weights	Supplier1	Supplier2	Supplier3	Supplier4	Supplier5
Cost	0.9	0.7311401	0.814624	0.80063775	0.60756014	0.509376067
Quality	0.8	0.5455146	0.6481586	0.66665244	0.47916264	0.636844108
Delivery time	0.7	0.7226967	0.6672504	0.58332504	0.67674104	0.700236833
Supplier management capabilities	0.4	0.5691097	0.4921343	0.60475003	0.17198271	0.473795774
Supplier non management staff capabilities	0.2	0.7570958	0.1931465	0.36439649	0.36600387	0.71260168
Ability to meet company requirements	0.6	0.4414848	0.5184574	0.46004101	0.61575503	0.540209802
Cost structure of the supplier	0.2	0.5781908	0.352414	0.21652358	0.49685426	0.588725804
Financial capabilities	0.35	0.6597249	0.4420041	0.35362768	0.73144096	0.211015323
Supplier infrastructure / facilities	0.3	0.354504	0.3392747	0.35401832	0.30604206	0.317232442
Process and Technological capabilities	0.1	0.2362806	0.1794006	0.18848173	0.20583061	0.240213882
Environmental regulation compliance	0.45	0.2577698	0.3830631	0.33423222	0.21541422	0.592568415
Information System capabilities	0.2	0.2532905	0.2967656	0.41545019	0.46056673	0.36512046
Long term relationships potential	0.3	0.3642836	0.5347022	0.49585815	0.35208056	0.182756726
Reliability	0.6	0.6262219	0.4554079	0.35057474	0.59728692	0.650244848
ISO 9001:2008	0.3	0.540823	0.1837057	0.25364684	0.38572269	0.470730072

Scores		Mean
Supplier1	3.53472	3.50083372
Supplier2	3.33073	3.16616628
Supplier3	3.21385	3.09333345
Supplier4	3.15183	3.22249999
Supplier5	3.35091	3.41466662

Table 9.6 WPM example: matrix with weight attributes using Monte Carlo simulation (own content)

	Final Scores	
	Supplier No	Score
1	Supplier1	3.53472
2	Supplier5	3.35091
3	Supplier2	3.33073
4	Supplier3	3.21385
5	Supplier4	3.15183

Table 9.7 WPM example: final scores with Monte Carlo simulation (own content)

Table 9.7 shows the final scores of every supplier. Now if we compare these values with the values of table 9.4, Supplier1 is still the best supplier among all the options. Supplier5 still holds 2nd position in the table but the values related to the scores of suppliers 2, 3 and 4 have been changed. In table 9.4, Supplier4 was considered to be the 3rd, Supplier2 on the 4th place and Supplier3 was the last one on the list. But these values of table 9.7 show different results, Supplier2 is considered as the 3rd, Supplier 3 holds position 4th and the last one on the list is Supplier4. This comparison between figure 9.4 and 9.7 is shown in the figure 9.8 below.

	Final Scores	
	Supplier No	Score
1	Supplier1	3.6425
2	Supplier5	3.3555
3	Supplier4	3.2775
4	Supplier2	3.2625
5	Supplier3	3.185

Table 9.4

	Final Scores	
	Supplier No	Score
1	Supplier1	3.53472
2	Supplier5	3.35091
3	Supplier2	3.33073
4	Supplier3	3.21385
5	Supplier4	3.15183

Table 9.7

Table 9.8 Comparison of final scores (own content)

The difference in the values of the two tables shows that the experiment has worked successfully. Monte Carlo simulation has provided different values for each supplier after running for 10.000 different iterations. The values of table 9.7 are more reliable because these values are obtained after a simulation, which has run for 10.000 times. It is clear from the values obtained that Monte Carlo simulation can help businesses to choose the right suppliers if they need 10 of suppliers out of 1.000 suppliers available.

The analysis has been performed in a much-detailed way, presenting all the possible details of each supplier. Figure 9.5 shows the detailed information of Supplier1; the mean of the values related to Supplier1 after a simulation run for 10.000 times is 3.500833656, while the standard deviation and variance are also observed. Beside the confidence value as well as some other important information is also observed and are shown in the right upper corner of the figure 9.5. This information gives a better insight of each supplier and thus makes it easy for businesses to see the statistics of all the suppliers. Same details are observed for all the other 4 suppliers.

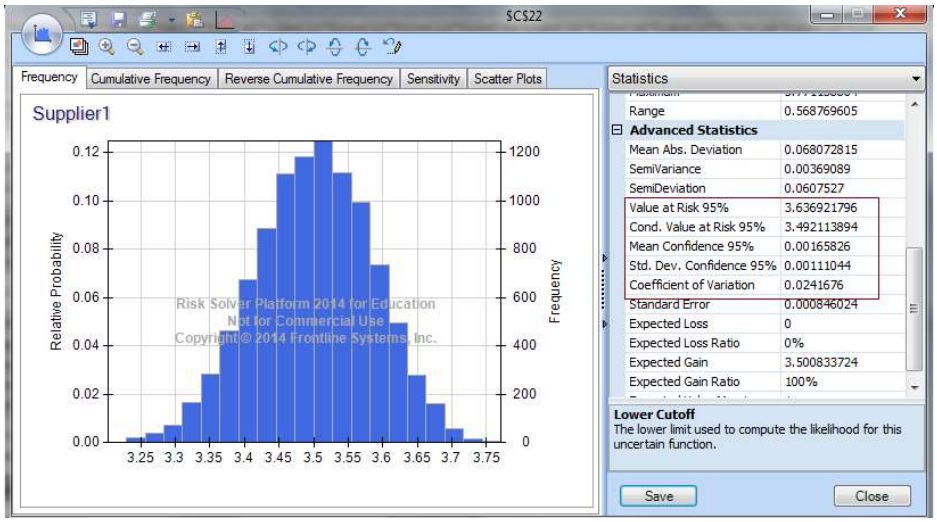


Figure 9.5. Experiment details of supplier1 (own content)

The suppliers are the actual business partners, and they can bring a lot of revenue. The aim of this section was to study how choosing the wrong suppliers can be a risk to the supply chain, and to find out ways to reduce the risks associated with suppliers by identifying processes to select the best suppliers. The use of Monte Carlo simulation in the supplier selection process

plays an important role and gives clear and detailed information to the procurement about the suppliers. The procurement can define their own scenarios and change the parameters as per their requirements to get their desired results. It is recommended that the future researchers focus on using this concept in the supplier evaluation.

9.6.2 Supplier Evaluation Concept Connected with Automated Spend Management Concept.

In this section, an automated supplier management process for the existing suppliers is presented, the proposed concept is the extension to the automated spend management concept presented in chapter7 and works only on the suppliers, which are already working for a company. The output from the automated spend management concept is considered as input for this process to run. “Weight Point Method” is used to evaluate and classify the suppliers. Below figure 9.6 shows the concept structure and the reporting which could be automated.

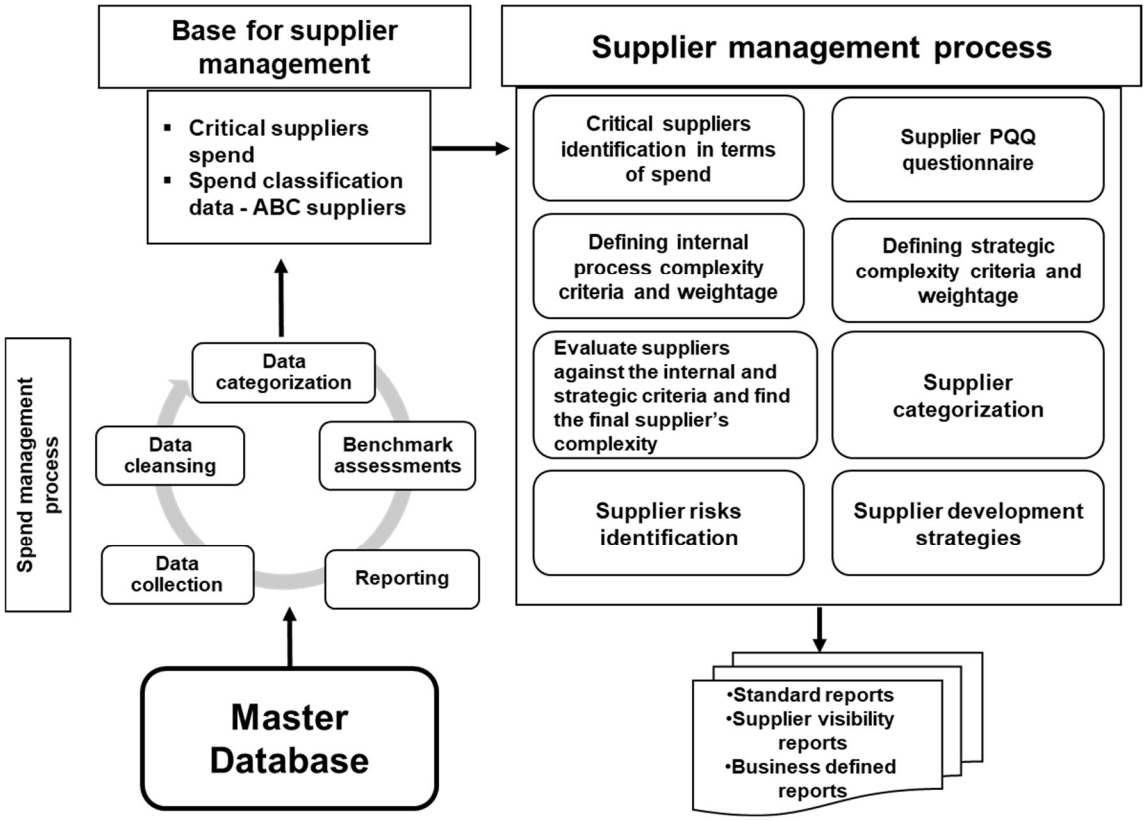


Figure 9.6. Proposed automated supplier evaluation concept connected to the automated spend management (own content)

The concept presented above works in 3 phases to achieve the goals, each step is explained below in more details.

Phase1: Identification of supplier complexity

Phase2: Evaluation of suppliers

Phase3: Classification of suppliers & reporting

To test this concept, I have taken the spend data of an exemplary company, with around 3.000 suppliers in an excel file; to each supplier I have allocated a random spend between 1.000€ and 40m€ in different categories, by this I have tried to bring the data to a level which could be comparable with the real business data. **This automated excel sheet is attached as an Annex (100 Critical suppliers Annex2) to see the data and process in more details.**

Phase1: Identification of supplier's complexity:

In Phase1, with the help of excel formulas the top 100 suppliers in terms of high spend as well as some other criteria have been identified. I have named them as critical suppliers here. Different businesses can choose a name which suits them the best. For the evaluation processes, businesses need the suppliers, who are important for them in different aspects, most relevant are in terms of internal processes and strategic importance. In my concept, I have kept both these accepts in mind and have named them as

a) **Internal process complexity:** This shows the performance of suppliers to perform against the internal processes, I have weighted these 70% for my experiments.
b) **Strategic complexity:** This shows the strategic importance of the suppliers for the company, I have weighted these 30% for my experiments.

The weightage for these complexities can be different in different businesses, and in my automated excel sheets, they can be changed or adjusted accordingly.

The identification process for these critical suppliers is done in 2 steps.

In step 1 the internal complexity of these suppliers is found out with the help of 4 important criteria with hard figures, these 4 important criteria are

- Spend in €
- Number of Items delivered
- Delivery to number of sites
- Number of purchase orders (POs)

A weightage has been given to all these criteria based on their importance, the details are in the Table below 9.9.

	Weight (%)					
Internal Process Complexity	70%					
Strategic Complexity	30%					
Internal Complexity Input		5	4	3	2	1
	Weight (%)	Very High	High	Medium	Low	Very Low
Spend	40%	>5M	5-1M	1M-0,5M	0,5M-10K	>10K
Items	20%	>50	49 to 25	24 to 10	9 to 2	1
Sites	35%	>6	5	4 to 3	2	1
Purchase Orders	5%	>500	499 to 250	249 to 10	9 to 2	1

Further details in Annex2

Table 9.9 Internal complexity input (own content)

Below table shows an example of the top 20 suppliers based on their internal complexity. Detail calculation is presented in ANNEX-2 where all the formulas and approach is mentioned in an excel sheet.

Step 1 (Finding Internal Complexity)							
Nr.	Supplier Name	Spend (EUR)	Spend Complexity Input	Items Complexity input	Site complexity input	PO compexity input	Internal Process Complexity
1	SupplierCor	1.571.631 €	4				4,5
2	SupplierBAM	12.365.792 €	5				4,7
3	SupplierBon	6.267.411 €	5	5	5	3	4,9
4	SupplierKUN	4.978.602 €	4	5	4	3	4,2
5	SupplierPro	24.178.421 €	5	3	3	3	3,8
6	SupplierEvo	9.423.660 €	5	3	3	4	3,9
7	SupplierVes	9.366.156 €	5	3	3	3	3,8
8	SupplierCla	1.607.825 €	4	5	3	3	3,8
9	SupplierDSM	9.148.440 €	5	3	3	3	3,8
10	SupplierDur	4.488.137 €	4	4	3	3	3,6
11	SupplierINE	6.322.406 €	5	4	3	3	4,0
12	SupplierBAS	5.869.844 €	5	3	3	3	3,8
13	SupplierTOT	3.306.005 €	4	3	3	3	3,4
14	SupplierSAB	2.536.700 €	4	3	3	3	3,4
15	SupplierPOL	1.549.862 €	4	3	3	3	3,4
16	SupplierTNT	156.521 €	2	3	5	4	3,4
17	SupplierPOL	9.805.463 €	5	3	2	3	3,5
18	SupplierELE	2.927.951 €	4	3	3	3	3,4
19	SupplierOer	262.968 €	2	5	4	3	3,4
20	SupplierMai	1.146.494 €	4	3	3	4	3,5

Further details in Annex2

Table 9.10. Internal complexity identification (own content)

In step 2, the strategic complexity of these suppliers is found out with the help of 2 more criteria, shown in table 9.11

- Strategic importance
- Level of attractiveness for BUSINESS, Innovative partner

	Weight (%)					
Internal Process Complexity	70%					
Strategic Complexity	30%					
Stategic Complexity Input		5	4	3	2	1
	weight (%)	Very High	High	Medium	Low	Very Low
Value/Business Impact for Customer (Strategic Importance)	80%	>5M€	1-5M€	1M-0,5M€	0,5-0,1M€	0,1M-10k€
Strategic/Innovative partner (Level of attractiveness for Customer)	20%	Strategic Critical	Strategic	Preferred	Collaborative	Transactional

Further details in Annex2

Table 9.11. Strategic complexity input (own content)

Below table 9.8 shows the calculation of the strategic complexity as well as the final complexity. The final complexity is calculated with the formula below.

Formula: Final complexity = (Internal process complexity weightage (70%) * value of Internal process complexity) + (Strategic complexity weightage (30%) * value of strategic complexity))

Step 2 (Finding Strategic and Final Complexity)						
Supplier Name	Value/Business Impact for Customer (Strategic Importance)	#Strategic importance	Strategic/Innovative partner (Level of attractiveness for Customer)	#Attractiveness	Strategic Complexity	Final complexity
SupplierCor	4	3,2	4	0.8	4.0	4,4
SupplierBAM	5	4				4,8
SupplierBon	5	4				4,9
SupplierKUN	4	3,2				4,1
SupplierPro	5	4	5	1	5,0	4,2
SupplierEvo	5	4	5	1	5,0	4,2
SupplierVes	5	4	5	1	5,0	4,2
SupplierCla	4	3,2	4	0,8	4,0	3,9
SupplierDSM	5	4	5	1	5,0	4,2
SupplierDur	4	3,2	4	0,8	4,0	3,7
SupplierINE	5	4	5	1	5,0	4,3
SupplierBAS	5	4	5	1	5,0	4,2
SupplierTOT	4	3,2	4	0,8	4,0	3,6
SupplierSAB	4	3,2	4	0,8	4,0	3,6
SupplierPOL	4	3,2	4	0,8	4,0	3,6
SupplierTNT	2	1,6	2	0,4	2,0	2,9
SupplierADE	4	3,2	4	0,8	4,0	3,5
SupplierSHI	4	3,2	4	0,8	4,0	3,5
SupplierPOL	5	4	5	1	5,0	3,9
SupplierNan	5	4	5	1	5,0	3,8

Further details in Annex2

Table 9.12. Strategic and final complexity identification (own content)

As an outcome of the above 2 steps, the final complexity is calculated. For calculating the final complexity, a weightage has been given to both the complexities i.e. “internal complexity”, “external complexity”. A weightage of 70% is assigned to the internal complexity because these values are based on figures while the rest 30% weightage is assigned to the strategic complexity.

Phase2: Evaluation of Suppliers:

The most important part of the SRM is to evaluate different suppliers; the evaluation is done with the help of a questionnaire, which is sent to the suppliers having high final complexity. I have tried to design the questionnaire in such a way, which should cover all the important dimensions of any business structure, these important dimensions are shown below.

1. Logistics
2. Commercial and contracts
3. Quality management
4. Sustainability management
5. Level of partnership

For each dimension, different criteria have been defined, which fit best to those dimensions along some short definitions in order to make it easier for the people who are filling this questionnaire. A weightage is also assigned to each dimension as well to each criteria to achieve the best possible results. Figures below show an overview of the questionnaire while **the detailed questionnaire along with test scores (which is the input for Phase3) is also attached to the supporting documents named as Evaluation_Classification, Supplier Reports_ANNEX3.**

Logistics (weighting 10%):

Evaluation Dimension			Questions				
No.	Name of Dimension	Weighting (%)	No.	Name of Criteria	Definition of Criteria	Ojective	Weighting (%)
1	Logistics						100%
1	Logistics	10%	1.1	Ontime Delive			10%
			1.2	Quality of Pac			10%
			1.3	Delivery quan			10%
			1.4	Delivery quali			10%
			1.5	Risk Manager			10%
			1.6	Flexibility			10%
			1.7	(Production)			10%
			1.8	Backup (facili			10%
			1.9	Availability			10%
			1.10	Reaction time	How would you rate reaction tim of the supplier in case of demand change?		10%

All details, can be found in readable form in Annex3

Commercial and Contracts (weighting 35%)

2	Commercial, Contracts						100%
2	Commercial and Contracts	35%	2.1	Accepetence of General purchasing	How would you rate the adherence of supplier to the General purchasing		10,00%
			2.2				10,00%
			2.3				10,00%
			2.4				10,00%
			2.5				10,00%
			2.6				10,00%
			2.7				10,00%
			2.8				10,00%
			2.9				10,00%
			2.10	Natural disasters	Rating of risk of natural disasters in origin-country of the supplier by using index "WorldRiskReport" - online under http://weltrisikobericht.de/english/	Risk mitigation in supply chain	10,00%

All details, can be found in readable form in Annex3

Quality Management (weighting 25%)

3	Quality Management						100%
3	Quality Management	25%	3.1	Customer Service Quality	The quality of the customer service provided by the supplier is fully satisfactory. (NOTE: Please evaluate customer service with respect to the actually signed Service Level Agreements (SLAs) and the contractually agreed response times and		9,09%
			3.2	Flexib			9,09%
			3.3	Emplo			9,09%
			3.4	Produ			9,09%
			3.5	Servic			9,09%
			3.6	React			9,09%
			3.7	Qualit			9,09%
			3.8	Incide			9,09%
			3.9	Qualit			9,09%
			3.10	Quality of overall Documentation	Does the company properly handle quality-relevant documentation?	due to poor documentation (specifications, analysis of problems)	9,09%
			3.11	Transfer of important documents	The supplier sends documents (Certificates of Analysis (COA), certicate of performance, accompanying document, etc.) to Customer on a regular basis.		9,09%

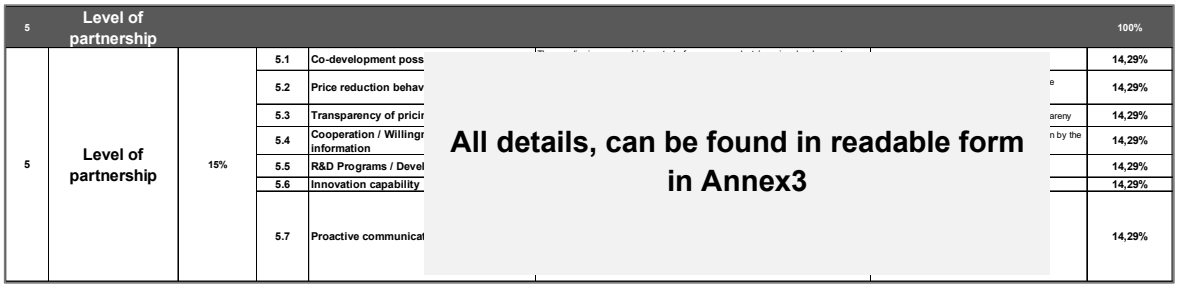
All details, can be found in readable form in Annex3

Sustainability Management (weighting 15%)

4	Sustainability Management						100%
4	Sustainability Management	15%	4.1	Occupational health and safety	The supplier actively engages in occupational safety and the prevention of		10,00%
			4.2	Safety of working e			10,00%
			4.3	Energy and resourc			10,00%
			4.4	Usage of restricted substances			10,00%
			4.5	Adherence to mode			10,00%
			4.6	Risk modern slaver			10,00%
			4.7	Political risk index			10,00%
			4.8	Mandatory certifica			10,00%
			4.9	Additional certifica			10,00%
			4.10	REACh Compliance	Declaration of conformity according to the REACH regulation by supplier		10,00%

All details, can be found in readable form in Annex3

Level of Partnership (weighting 15%)



Phase3: Classification of Suppliers & Reporting

At this phase of the process, the suppliers are classified into A, B and C. “A” supplier(s) are the ones which are very important for the business and are evaluated in the above 5 criteria. In order to perform a small experiment, I have taken four suppliers mentioned below from the 100 critical suppliers list and have assigned test scores in the evaluation questionnaire.

1. SupplierBAS, 2. SupplierROW, 3. SupplierJOH, 4. Supplier ADE

Based on the input from the evaluation questionnaire, following values have been obtained and further classification calculation is performed with below values.

Supplier Name	Dimension	Dimension weightage	Supplier Score
SupplierBAS			
	Logistics	10%	72%
	Commercial and contracts	35%	68%
	Quality management	25%	75%
	Sustainability management	15%	90%
	Level of partnership	15%	57%
SupplierROW			
	Logistics	10%	88%
	Commercial and contracts	35%	92%
	Quality management	25%	84%
	Sustainability management	15%	90%
	Level of partnership	15%	89%
SupplierJOH			
	Logistics	10%	78%
	Commercial and contracts	35%	76%
	Quality management	25%	76%
	Sustainability management	15%	86%
	Level of partnership	15%	69%
SupplierADE			
	Logistics	10%	72%
	Commercial and contracts	35%	72%
	Quality management	25%	80%
	Sustainability management	15%	86%
	Level of partnership	15%	66%

Table 9.13. Evaluation score of for 4 test suppliers (own content)

To develop the supplier classification graph, these values are represented into 2 Axis and overall score. On X-Axis, the level of Partnership is measured whereas on the Y-Axis the level of performance is measured. The values for both these Axis and overall score are calculated as below.

X-Axis values: *The sum value of all criteria values for level of partnership*

Y-Axis values: *(Supplier score in logistics * Weightage of logistics + Supplier score in commercial and contracts * Weightage of commercials and contracts + Supplier score in quality management * Weightage of quality management + Supplier score in sustainability management * Weightage of sustainability management)/85*100*

Overall score: *(Supplier score in logistics * Weightage of logistics + Supplier score in commercial and contracts * Weightage of commercials and contracts + Supplier score in quality management * Weightage of quality management + Supplier score in sustainability management * Weightage of sustainability management + Supplier score in Level of partnership* Weightage of level of partnership)*

After calculating all these values, following results shown in table 9.14 are obtained for all the 4 suppliers included in the experiment.

Supplier Name	X-Axis value	Y-Axis value	Overall Score
SupplierBAS	57%	74%	72%
SupplierROW	89%	89%	89%
SupplierJOH	69%	78%	77%
SupplierADE	66%	77%	75%

Table 9.14. X-Axis, Y-Axis value and overall score of the 4 test suppliers (own content)

Based on the above values and with the help of SERIES formula in excel, the supplier classification graph/card is prepared, the formula used is mentioned below.

Formula:

SupplierBAS: = SERIES (SupplierBAS; X-Axis value; Y-Axis value; 1; {1})

SupplierROW: = SERIES (SupplierROW; X-Axis value; Y-Axis value; 2; {1})

SupplierJOH: = SERIES (SupplierJOH; X-Axis value; Y-Axis value; 3; {1})

SupplierADE: = SERIES (SupplierADE; X-Axis value; Y-Axis value; 4; {1})

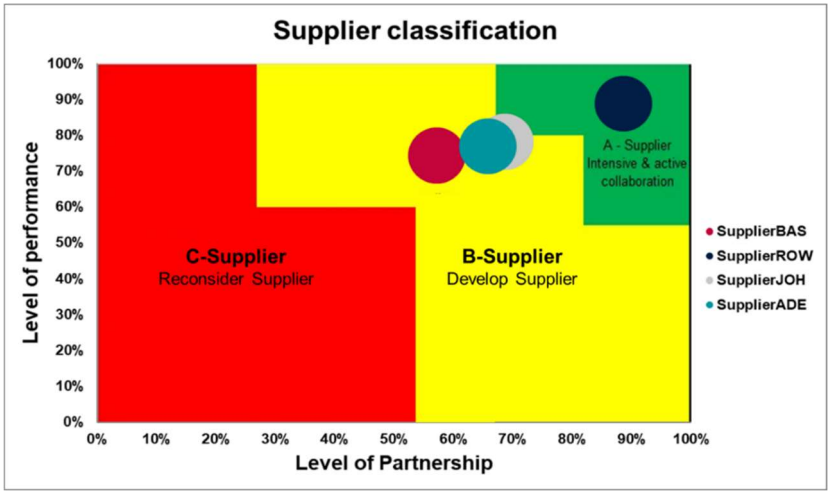


Figure 9.7. Supplier classification result (own content)

Figure 9.7 shows that the suppliers are classified into different levels based on the input gathered from different sources. As a next step, the performance of all suppliers is compared with the target performance of the company individually, here the company needs to set targets for their supplier to achieve in all the dimensions. Below example shows a sample report, which I have created for SupplierBAS and have defined company targets in all the 5 dimensions shown in table 9.15 and the graphical representation (supplier one-pager) in figure**. Further details of these suppliers and test score, calculation, formulas etc. are mentioned in Evaluation_Classification, Supplier Reports_ANNEX3**

Dimension	Evaluation Result	Company Target
Logistics	72%	80%
Commercial, Contracts	68%	80%
Quality Management	75%	80%
Sustainability Management	90%	90%
Level of partnership	57%	80%

Table 9.15. Evaluation results with company targets (own content)

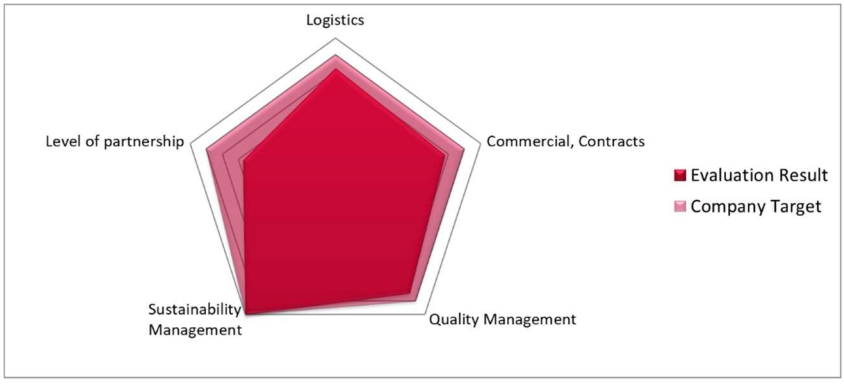


Figure 9.8. Supplier one-pager (own content)

The figure 9.8 shows the performance of the SupplierBAS in all the 5. dimensions against the companies set targets. SupplierBAS can easily identify from the above report, that they need to work on the dimension “Level of partnership” in order to sustain in the business.

My proposed concept ensures that automated supplier reports are generated and are sent to the supplier on monthly basis, where the supplier can see if they are on track with the expectations of the customer or if they need improvements.

Many automated user reports can be designed according to the need of the company, which could bring many benefits to the overall process, some possible benefits are mentioned below.

- One global process and procedure for supplier collaboration approach.
- Defined criteria for selection of suppliers for supplier evaluation.
- Identification of critical suppliers.
- SMART and lean supplier evaluation
- Definition of measurements after evaluation.
- Automation and support of supplier collaboration
- Improvements for current processes and procedures.
- One general questionnaire for supplier evaluation.
- Category specialized questions (if needed).
- Standardized Supplier on boarding and pre-qualification process.
- Supplier collaboration KPIs to be transferred to Group Procurement KPI-Dashboard.

These reports could be door openers for further supplier-company communication and improvements and could also contribute to the overall supplier relationship process

9.7 Chapter Conclusion

Supplier management is one of the most important part of the strategic procurement process. It is the process to manage your suppliers properly and to achieve maximum value for your organization; it is a process of continuous improvement. Supply risks are the most common risks associated to any supply chain, but their impact on supply chains could be devastating, that is why these risks should be properly identified and should be mitigated at the earliest.

In order to mitigate the supply risks, it is important to focus on supplier selection, evaluation and classification processes, by choosing the correct and right number of suppliers for any business. The prime goal of the supplier selection process is to reduce the risk in procurement and to maximize the overall performance in order to develop a long-term relationship between the procurement and the supplier. A correct and sound supplier selection decision today can reduce the losses and problems of tomorrow. Suppliers offering the lowest prices is not an efficient sourcing strategy anymore, multiple criteria need to be considered when selecting suppliers.

To select the right suppliers for any business, it becomes important to correctly perform the supplier selection and evaluation process. The supplier selection process requires a great amount of the procurement financial resources, that is why it is important to focus on the existing suppliers, manage them properly and maintain a great relationship to achieve the common goals. The supply chain risks should be taken very seriously as it can affect the actual supply chain operations, which leads to a bad reputation of any organization. The risks associated with the suppliers must be properly identified because they can lead to a vital damage to the entire supply chain operation.

Chapter 10: Risk Mitigation Associated with Demands with Monte Carlo Simulation

Demand management is an important part of procurement, and it is considered as a crucial process by the procurement professionals to achieve the organizational targets. In the ever-changing business environment, the supply chains are bonded in collaborations, resulting in an effective demand management process, crucial and challenging.

Demand risks are one of the most prominent risks associated with any supply chain. Demands are the soul for collaboration and the companies working in collaborative network must achieve a great level of demand management to achieve their common goals.

A small error in the demand planning can lead to devastating results for businesses, therefore, the demand risks should be taken very seriously and must be identified and mitigated well in time. The aim of the chapter is to analyse the risks associated with demands and use possible methods to mitigate these risks. I have also tried to use the Monte Carlo simulation model on a high level to mitigate the risks associated with demands.

10.1 Demand Management

Demand management is a procurement process directly related to the supply chain management; it balances the requirements of the customers with the capabilities of supply chain. The demand management is a critical process of the supply chain management; with the right process in place, the businesses can fulfil the supply and demand proactively and execute their plans with minimal disruptions (Croxton, 2002).

A proper and accurate demand management process has always been a priority for procurement since the beginning. An important target of demand management is to find ways to reduce demand variability and improve operational flexibility, this reduction of demand variability can result in great savings for any organization (Croxton, 2002).

10.2 Supply Chain Risks Impacting Demand

Supply chains are prone to different risks which impacts different parts of supply chain. The following are the risks of supply chain, directly impacting demands.

10.2.1 Demand Risk

The demand risk is the most frequent risk associated to supply chains. As in the saying "customer is always right", it is very difficult to forecast the right demand because there are many elements which revolves around the demand. Different authors have defined the demand risks in different ways, according to (Makers, 2001) (Cranfield, 2013) "Demand risk relates to potential or actual disturbances to the flow of product, information, cash, emanating from within the network, between the focal company and the market. The demand risk can be a failure on either the high or low side to accurately accommodate the level of demand".

The demand risk can be the result of an unpredictable demand, miscommunication with the customer or customer demand itself (Queenland, 2013).

The demand risk may arise due to an unexpected increase or decrease in customer demand that results into a mismatch between the forecast and actual demand of the company.

(Lall, 2011) and many other authors write in their reports that, an increase in the customer demand leads to depletion of safety stocks, resulting in stock-outs and back orders while on the other hand a fall in the customer demand leads to increased holding costs and price reductions. (Lawton, 2007) describes a demand risk as the fluctuations in demands and inventory. Figure 10.1 shows the possible demand risks to any supply chain.

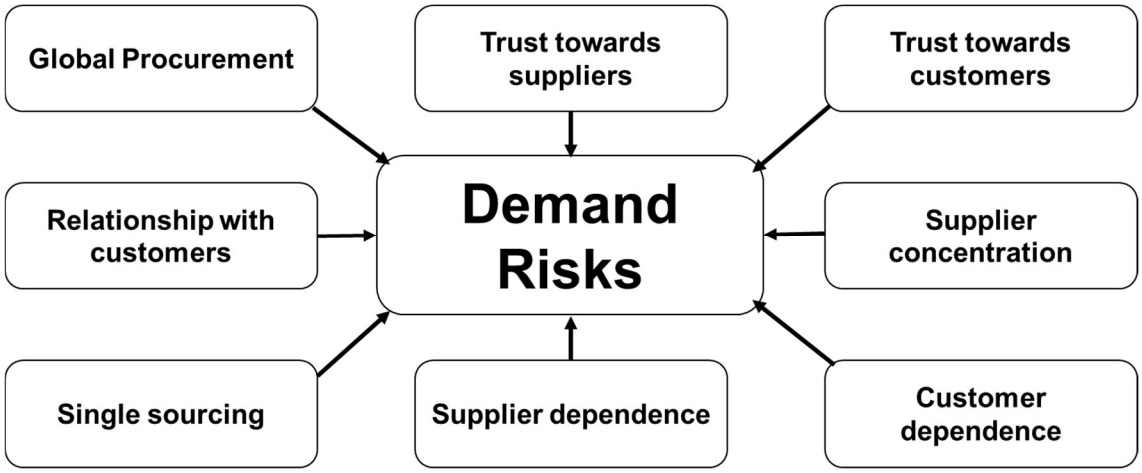


Figure 10.1. Demand risks. figure based on (Mandal, 2012) *with modifications*

In real world the demand risk is taken seriously by every organization, the companies are aware of the demand risks within their supply chain. Many logistics specialists in different organization have the job to accurately estimate the forecasts in order to save costs. Different types of forecasting techniques are used by supply chain specialists to properly identify the forecasts. The demand risk is one of the most common risks to the supply chain industry, that is why it is important to identify the demand risks proactively and these risks should be mitigated as early as possible. If these risks are not taken seriously, it can have a costly impact on the business and the entire supply chain, as all the elements of the supply chain are very strongly inter-connected. Further to the demand risks, below are some more risks which have a direct impact on the demand fluctuation when they occur.

10.2.2 Geopolitical Risks

Politics plays a vital role in today's global supply chains with collaboration, this risk is also a vital risk to the supply chain industry, it can have a great impact on the supply chain operations and demand fluctuations. Every business, which is involved in the flow of goods and deals with the emerging markets, is exposed to geopolitical risks. Although there are many suppliers of raw materials and other goods in the emerging markets, but the geopolitical risks are also significant and can have an impact on the bottom-line profit of the businesses (Monaghan, 2011).

The geopolitical disruptions consist a range of potential disruptions, which include conflicts and unrests, terrorism, corruption, and organized crime.

The effects of terrorism on global supply chains are illustrated by a cumulative increase in expenditure of over US$ 1 trillion in the US domestic homeland security since 9/11, as well as a range of new industry regulations and requirements across supply chain and transport networks (Appel, 2012). In the recent times, Brexit is already having an impact on the demand fluctuations in many major industries.

10.2.3 Economic Risks

The Economic risks also have a great and direct impact on the demand fluctuations, the demand risks automatically increase as soon as the economic risks occur. The economic risks cover a wide range of disruptions which include currency fluctuations, sudden demand fluctuation, commodity price volatility, border delays and investment restrictions. Many of these economic risks have been highlighted by the global financial crisis in 2008 and the current Eurozone crisis (Appel, 2012). The report further states that following the 2008 financial crisis, annual filings for supplier bankruptcy within the automotive sector roughly doubled from 2007 to 2008

- **Demand sudden fluctuation 44%**
- Extreme instability in commodity prices 30%
- Border delays 26%
- Currency fluctuations 26%
- Global energy shortages 19%
- Ownership/investment restrictions 17%
- Labour shortage 17%

10.3 Bullwhip Effect

In any supply chain, different organizations and participants work together in a chain to achieve their targets effectively and efficiently, but sometimes this chain of supplies faces some inefficiencies, and one of the most common reason for it is the bullwhip effect. Small fluctuation at one end can lead to large fluctuation at the other end. In the supply chain context, how a small fluctuation in demand at the customer level can cause progressively larger fluctuations in demand at the retailer, distributor, manufacturer, and raw material supplier level (Daniel, 2019). Below figure shows a typical Bullwhip effect from customer to supplier.

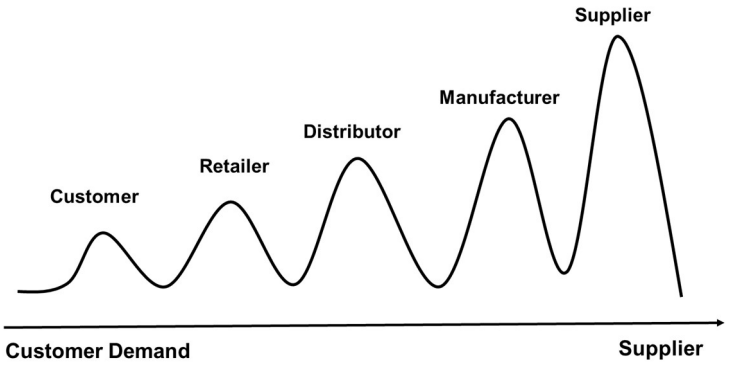


Figure 10.2. Bullwhip effect: figure based on (Norris, 2020) *with modifications*

Bullwhip mostly affects the demand forecasted supply chains, rather than a supply chain that is working on actual customer demand. Suppose a customer buys 50 product1 every day from a retailer, but one day the customer buys 100 product1, the retailer assumes that the demand of product1 has increased, and customer is buying more, therefore he responds by ordering 200 product1 to meet this higher forecasted demand from the distributor. The distributor may then also assume the same and order 400 product1 from the manufacturer, seeing this change in demand the manufacturer produces 500 product1 to be on the safe side. In the end, this small increase in the customer demand amplified up the supply chain from 50 to 500, this is the bullwhip effect. There are many factors which contribute to the bullwhip in a supply chain, some prominent of them are 1. Lack of communication. 2. Disorganization, 3. Free return policies, 4. Order batching etc. (Admin, 2012).

Bullwhip effect is a reality and cannot be eliminated from a supply chain completely, but rather its impact could be reduced by implementing some measures in a supply chain. According to (CIPS, 2020), the bullwhip effect can be reduced through share knowledge with suppliers and customers – it means that the information transparency between the customers and suppliers plays an important role to reduce the bullwhip effect. (Grainger, 2020) has provided some recommendations below to reduce the bullwhip.

1. Communicating Clearly Along Your Supply Chain
2. Improving Data Sharing to Increase Supply Chain Visibility
3. Reducing Lead Times and Cutting Down on Delays
4. Limiting Order Sizes
5. Consistently Monitoring Min-Max Inventory Levels
6. Advanced Information Technology (Automation)
7. Maintaining Consistent Pricing

10.4 Results and Discussion

At this phase of the research, it demonstrates that Monte Carlo simulation is used with Microsoft excel to perform the risks analysis associated with demands, the main target is to reduce the Bullwhip effect with the help of some experiments. In this research, Monte Carlo simulation is used to analyse the risks of the supply chain and the results have shown that a small demand fluctuation can have a big impact on the supply chain costs.

Monte Carlo simulation is a computerized mathematical technique that allows firms and users to account risk in quantitative analysis and decision-making. Monte Carlo simulation is also called probability simulation and this technique is used to understand the impact of risk and uncertainty in financial, project management, cost and other forcasting models.

The Monte Carlo method is distinguished from other techniques in numerical analysis by the use of random sampling to construct the solution of a physical or mathematical problem (Cashwell, 1975). "Monte Carlo simulation provides a range of possible outcomes and the probabilities of occurrence for any choice of action for a decision maker.

10.5 Simulation Experiments

In order to give a clear overview of Monte Carlo simulation mitigating risks with demand forecasting, a sample data is presented to conclude the impact. The concept can be

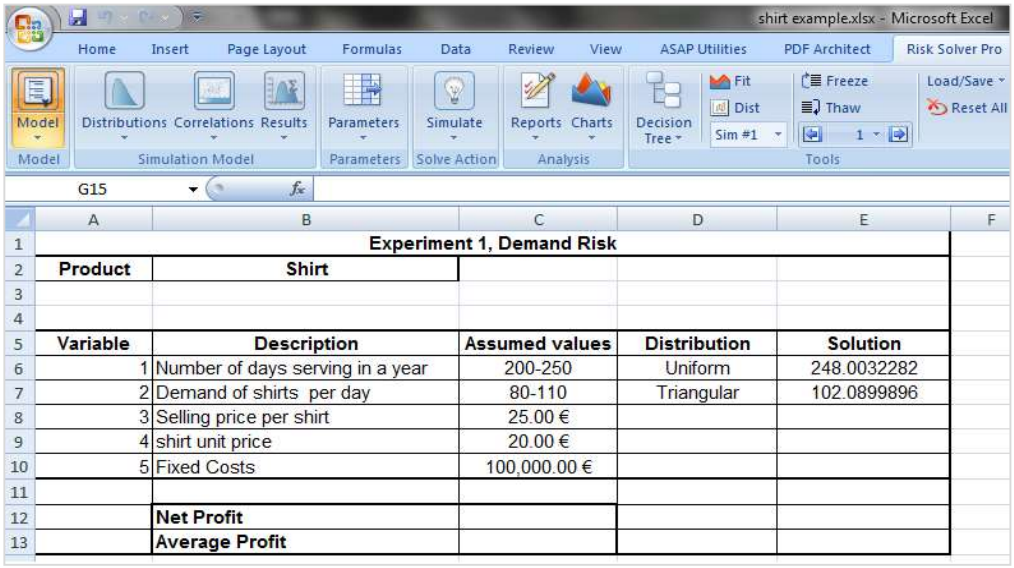
implemented to a large population data in the real world. In the experiment an example is presented, where the demand structure has been changed, and the impact is observed after the simulation is run for around 10,000 times.

The idea is to capture the reaction of the supply with the simple example, it can be further expanded to a bigger problem and the reaction of the supply chain can be observed. In order to perform Monte Carlo analysis in Microsoft excel, a Monte Carlo simulation's ADD-IN for excel has been used, which is called Risk Solver Pro (Solver, 2014).

In the experiment, a simulation for 10,000 times has been executed to obtain the desired results. The experiment shows that a company named as “ABC” is manufacturing one type of shirts, which are sold in the market.

The company operates between 200-250 days in a calendar year depending on the situation, the actual operational days are not known, but the lower and higher operational days are assumed to be ranging from 200-250 days in a calendar year. As the actual operational days are uncertain, a uniform distribution has been used to address uncertainty. This distribution has been shown in cell E6 of figure 10.3. There is a built-in function**" =PsiUniform(240,250,PsiName(B6))"** in the Risk Solver Pro platform, where the upper and lower limits have to be given.

Another uncertain variable has been taken into consideration, which is the “demand of shirts per day” because the demand is unknown. But it is assumed, that company ABC had a demand of 80 shirts per day in an off-season, the demand in normal seasons (most likely) is 100 shirts per day and the demand in the peak season is 110 shirts per day. As the demand, value is uncertain, so a triangular distribution has been defined for the demand with low, average, and upper limit. A built-in function **" =PsiTriangular(80,100,110,PsiName(B7))"** is used for the triangular distribution in the Risk Solver Pro platform, the values of lower, average and upper demand are given as the parameters. The selling price of a single shirt is 25 Euros. The unit price per shirt is 20 Euros, and the fixed costs per year is 100,000 Euros.



	A	B	C	D	E	F
1		Experiment 1, Demand Risk				
2	Product	Shirt				
3						
4						
5	Variable	Description	Assumed values	Distribution	Solution	
6	1	Number of days serving in a year	200-250	Uniform	248.0032282	
7	2	Demand of shirts per day	80-110	Triangular	102.0899896	
8	3	Selling price per shirt	25.00 €			
9	4	shirt unit price	20.00 €			
10	5	Fixed Costs	100,000.00 €			
11						
12		Net Profit				
13		Average Profit				

Figure 10.3. Demand risk experiment (own content)

At the end, the net profit is obtained using formula 10.3.1. as shown below, and the average profit is taken as the mean shown in formula 10.3.2. For taking the average profit a built in formula of the Risk Solver Pro is taken.

Formula 10.3.1. ***Net Profit = ((Number of days serving in a year x Demand of Shirts Per day x Selling Price per Shirt)-(Number of days serving in a year x Demand of Shirts per day x Shirt Unit Price))-Fixed Costs.***

Note: The number of days serving in a year and Demand of shirts per day are uncertain therefore, the values used in the simulation are the values from the distribution stated above.

Forumula 10.3.2*: Average Profit = PsiMean(Net Profit)*

With all the above values, the simulation has been executed in the Risk Solver Pro excel platform, and run for 10,000 times, figure 10.4 shows the simulation output.

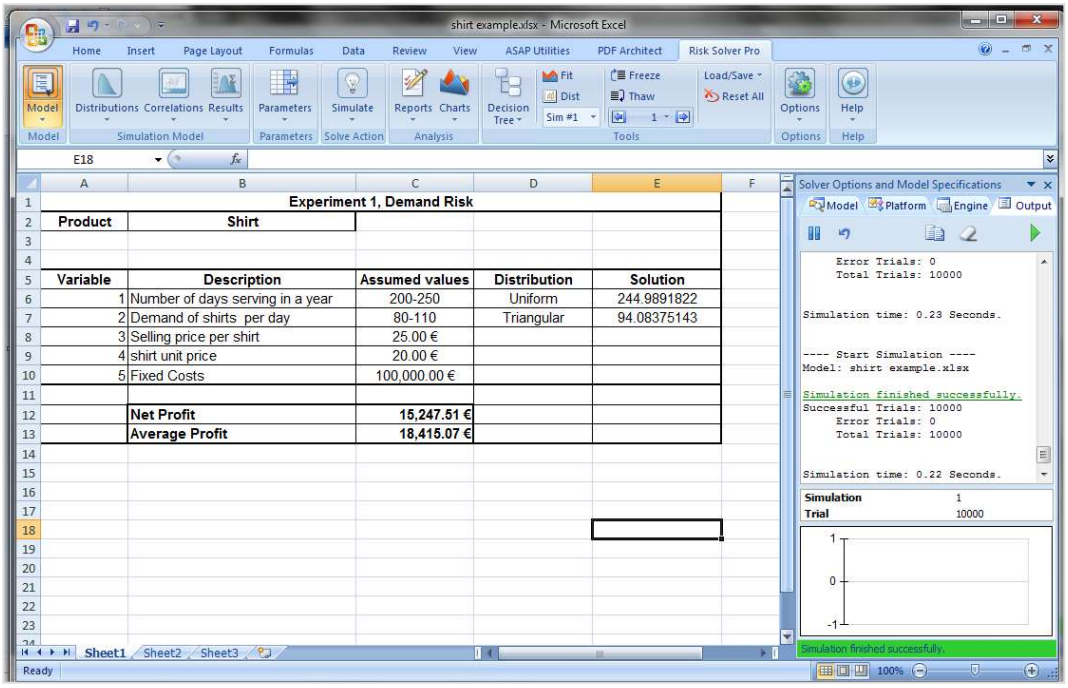


Figure 10.3(a). Demand risk experiment (own content)

It is clear from figure 10.3(a), that the simulation is executed 10,000 times in a very short span of time i.e., 0.22 seconds. The net profit as per the above values and demand is around 15,247 Euros, while the average profit is calculated as 18,415 Euros.

10.5.1 Results of the Simulation Model (1st phase)

As stated above, the simulation is run for 10,000 times, the results of the simulation are presented in figure 10.3(b). Risk Solver pro is a good platform which provides the simulation's results in detail. Figure 10.3(b) shows interesting facts, with the above demand and values, company ABC has 99.37% chances to earn profit. Further, it shows that the company can get a maximum profit of around 36,388 Euros, while there is a possibility of 0.63% to lose money and the loss can be of around 2,441 Euros. This information is highlighted square lines in red in the figure 10.3(b).

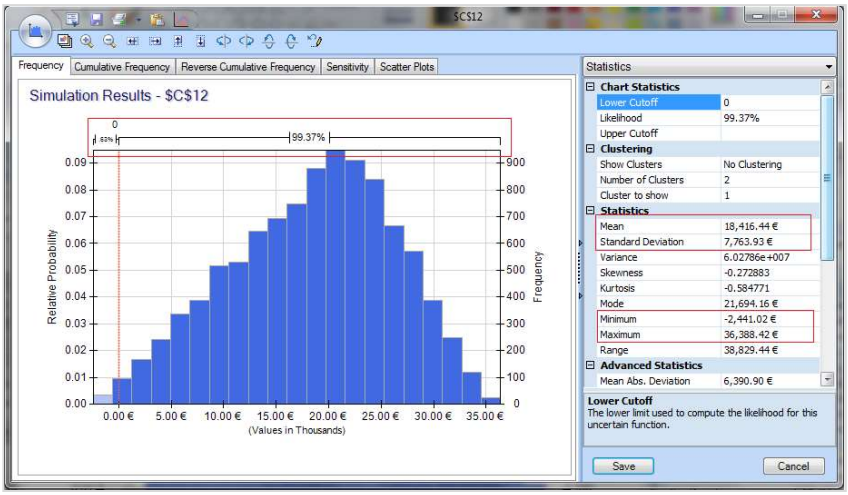


Figure.10.3(b) Demand experiment (own content)

Monte Carlo simulation embedded with the Risk Solver Pro platform is helpful for the businesses of today; the result gives useful information, which are important for supply chain procurement.

Figure 10.3(c) shows some additional information as well; it shows the importance of the demand in the above situation. As the company ABC is already in profit with given values, the additional information shows that, if the demand of the shirts grows, the profit of the company also increases.

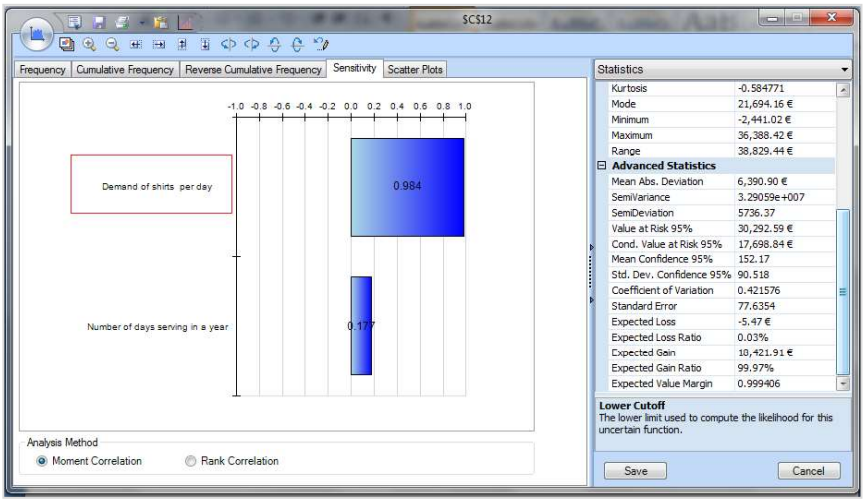


Figure.10.3(c) Demand risk experiment (own content)

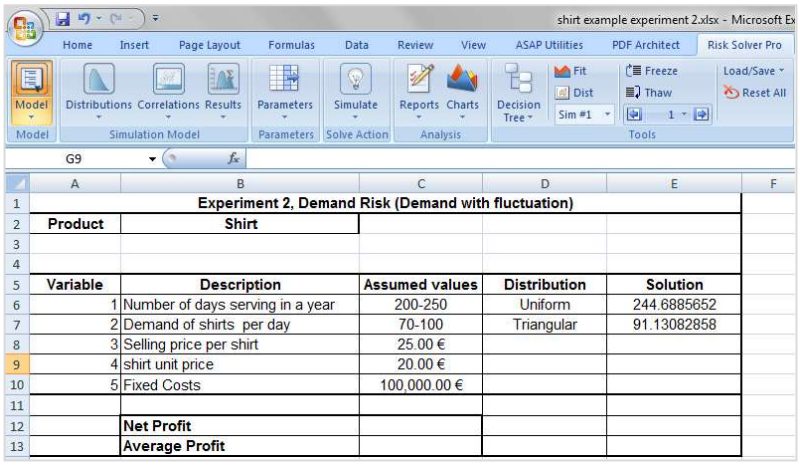
In the next phase of the experiment with the same values, the demand has been fluctuated and the reaction of the simulation on the total costs has been observed.

10.5.2 Demand Risk Experiment with Demand Fluctuation

In the previous experiment, after 10,000 iterations, the company ABC has a 99.37 % chance to be in profit. Now the demand has been fluctuated, while the other parameters remain unchanged.

It has been observed that the supply chain profit is affected by the demand fluctuation after running 10,000 times with the Monte Carlo simulation. The demand parameters have been changed as, lower limit demand of 70 shirts per day, most likely demand of 90 shirts per day and the high possible demand of 100 shirts per day. The same built-in function" **=PsiTriangular(70,90,100,PsiName(B7))"** is used here as well.

Figure 10.4 shows the initial values with fluctuated demand



	A	B	C	D	E	F
1		Experiment 2, Demand Risk (Demand with fluctuation)				
2	Product	Shirt				
3						
4						
5	Variable	Description	Assumed values	Distribution	Solution	
6	1	Number of days serving in a year	200-250	Uniform	244.6885652	
7	2	Demand of shirts per day	70-100	Triangular	91.13082858	
8	3	Selling price per shirt	25.00 €			
9	4	shirt unit price	20.00 €			
10	5	Fixed Costs	100,000.00 €			
11						
12		Net Profit				
13		Average Profit				

Figure.10.4. Demand risk experiment with demand fluctuation (own content)

10.5.3 Results of the Simulation with Demand fluctuation

After running the simulation for 10.000 times; it is observed that the little fluctuation in the demand has a great impact on the overall cost. The profit probability of the company ABC has been reduced from 99.37% to 77.11% and the possibility that the company ABC will lose money has been increased to 22.89%. Figure 10.4(a). shows the simulation results in a graphical representation with the percentage of loss and profit.

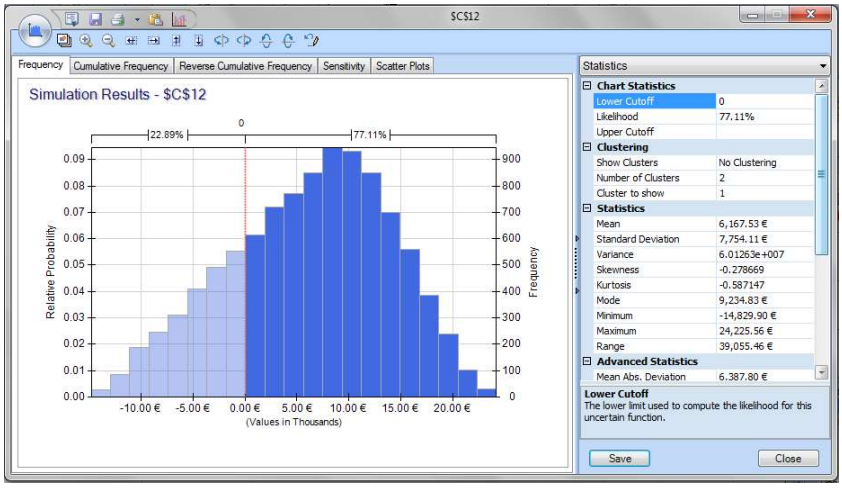


Figure.10.4(a). Demand risk experiment with demand fluctuation (own content)

The simulation results further show the mean value and the standard deviation of the experiment with demand fluctuation.

Furthermore, it is observed, that the company ABC can achieve a profit value of around 23,754 Euros and it can lose around 15,199 Euros with demand fluctuation.

If changes are made in the demand, the simulation provides different values each time, but the fact remains the same that with the demand fluctuation there is a certain influence on the overall costs of the supply chain. As the demand increases the revenue of the company increases, and as the demand decreases, the revenue of the company decreases.

In the experiment a simple example has been taken to show a relationship between the demand fluctuation and the overall supply chain costs, if the simulation is applied to a more complex experiment where all the elements of supply chain are included i.e., supply, production etc., the demand fluctuation will have a great impact on the overall elements and costs.

10.6 Chapter Conclusion

In any supply chain, it is important to keep a close eye on the demand fluctuation, the procurement should be aware of the impact, which could be caused to supply chain with demand fluctuations. They should study the market for experience and use effective techniques to forecast the demand.

An effective demand management process is the need of time in this competitive and collaborative business environment, which could lead to the success of any organization. The benefits of using modern demand management should not be underestimated and the companies should invest for business sustainability in the long run. A small fluctuation in the demand can lead to increased cost and huge reputational loss results for businesses.

The demand risks associated with supply chains must be taken very seriously because they can affect the actual operations, which lead to a bad reputation of the business firms. The risks associated with the demands must be properly identified, analysed, and mitigated. Monte Carlo simulation can provide a platform to investigate the future, therefore the using Monte Carlo simulation models in the demand management process can help the firms for effective forecasting and reduce the risks related to demand fluctuations.

Future researchers should investigate the implementation of Monte Carlo simulation concept to ensure better demand management and forecasting. In the earlier chapters of my research, I have introduced concepts, which could bring transparency (who is buying what from whom) to the procurement processes, those could be helping to reduce the impact of demand related risk to a supply chain.

Chapter 11: Thesis Summary

The objective of this research is, to analyse how the supply chain risks can be managed effectively, what are risks associated with the procurement processes and how automation of all the procurement processes will improve the overall performance of procurement. This research has been performed, keeping the automation and digitization challenges faced in the procurement industry in mind.

With the current growth in technology, the world has become a global home rather than a global village, and in the race of globalization, all the organizations have the common goals of saving cost, grabbing more customers, and leading the business market. In order to achieve these goals, it is necessary that the businesses across the globe must be bonded in collaborative networks. Due to collaborations and the fast growth in technology, the supply chains have become very complex and challenging, leading the supply chain prone to risks. These risks have a greater impact on the supply chain industry and as procurement is a vital part of supply chain, automatically the impact will hit the procurement part as well and will make supply chain more prone to risks. Thus, these complexities have made the procurement processes, time consuming and very costly.

In earlier days, the prime focus of the supply chain management used to be on material, financial and information flow, but in recent times, the focus has become broader and all the risks which have a direct or an indirect influence on the supply chain are taken in scope as well as in planning and execution of the processes. Risks are always associated with supply chain and could be internal or external.

Supply chain risk management is currently more critical than ever in all sectors of the industry. The potential impact of the supply chain risks on the core business and reputation of an organization cannot be underestimated. The supply chain leaders are getting smarter and by implementing complete and proactive risk management approaches together with the suppliers, it is possible to mitigate the risks completely, or to reduce the exposure to risks and its catastrophic impact on the business. Companies can reduce or limit the impact of the supply chain disruptions by identifying the risks within their supply chains and developing the right ways and strategies to mitigate them. Risk management identifies and develops strategies to coup with unknown events, which may occur and may influence organizational performance level or output.

Risk management process is a systematic approach to identify, quantify, manage, and communicate risk. Once the risk assessment is done, a specific approach is selected to treat the risk in order to minimize or eliminate risks, or plans are made to reduce the negative effects of the risks. If the risks are unavoidable, a risk management plan is developed to resume the operations of organization as early as possible to restrict the damage under an acceptable limit. Risk assessment is one of the most important steps of the risk management process, the better the risk is assessed, the better the solution is provided. There are different risk assessment methods proposed by many researchers i.e., FEMA, PPRR, Bowtie, What-If Analysis, and many others, but these methods differ in different organizations and businesses and risk managers should adopt the ones, which suit best for their business

Digitization of the process has the power to reduce or mitigate the risks associated with supply chain; many methods can be used to serve the purpose. Blockchain technology is proposed

as a risk mitigation technique in this research. Blockchain is a special form of distributed ledger technology with some extra feature to serve as database. The database is distributed and shared amongst the stakeholders in an encrypted form. Blockchain is tamperproof, irreversible, and hacking proof, it is decentralized ledger of records and ownership of an asset that can record and monitor any type of transaction distributed across the entire supply chain.

Blockchain technology has the ability to integrate all elements of supply chain and record data in a decentralized manner. This provides transparency among the stakeholders with the ability to track all information, such as material, products, and finances within a supply chain. Blockchain can provide an environment of trust within the entire supply chain by making everyone accountable for their own actions as it maintains records of each transaction of communication amongst the stakeholders in the supply chain. With the implementation of Blockchain technology in a supply chain, the overall performance of supply chain would be improved i.e., visibility, traceability, demand forecasting, access of information etc., that would reduce the associated risks with supply chain. The proposed solution in this research provides the possibility to trace and track the products during complete supply chain from the beginning to the end as well as during transportation. The flow of products can be more visible with the use of blockchain technology, which provides more control, flexibility, and optimized flow of product during complete supply chain.

Procurement is one of the most important part of supply chain management. If the procurement processes are properly executed, the remaining steps of supply chain will be automatically improved which would produce better results in terms of cost-savings and customer satisfaction. Although, it has not got much attention in comparison to other parts of supply chain management, but procurement should also be taken more seriously, and its processes need to be improved with the passage of time and with digitization. The success of any organization is dependent on the procurement processes. Procurement does not only deal with buying goods and services for any organization, but rather it manages the whole parties, suppliers, contracts, spend related to the goods and services bought for any business.

Many people use the terms procurement and purchasing as identical, these terms do have similarities, but they are not the same. Purchasing is a narrow and simple function in any organization, and it means to buy something for a specific price, while procurement has a wider domain and includes the entire process through which resources, services, people, facilities, and material for any project are obtained. If procurement of an organization is not performing well, it would have an impact on the overall performance of supply chain and if the procurement is in the right direction, it would result in great cost savings and increase the overall performance of supply chain.

Procurement can be divided into three types i.e., Operational, Tactical and Strategic procurement and in order to match the digital revolution of supply chain. Operational procurement commonly known as P2P (Procure to pay) or R2P (Requisition to pay), is the process of requisitioning, purchasing, receiving, and paying for the good or services needed. This process is the actual purchasing process of the procurement. The name comes from the ordered sequence of procurement and the financial processes, starting with the first steps of procuring goods or services to the final steps of paying for it. Tactical procurement refers to the short-term plans up to 1 year and transactional activities to keep the business running smoothly. Strategic procurement also known as P2S (Plan to Strategy), refers to long term

organization-wide plans to ensure timely supply of goods and services which are crucial and critical for the business, it also focuses to reduce suppliers, identifying critical suppliers and maintaining long term relationships with strategic suppliers. The automation of procurement processes is the need of time, and in this research, different automation concepts have been proposed to automate all the procurement processes.

Automation of the operational procurement would reduce the overall business costs and would increase the transparency level of the spend. The cash flow management would become more effective and efficient, the workflows would be streamlined. It will also empower the end users to procure by themselves against the agreed terms and prices of the strategic procurement department. Further, P2P departments could focus on more strategic topics and bring more value to the organization.

Tactical Procurement defines short terms strategies and plans up to 1 year to keep the business running smooth and consists of different independent processes. The tactical procurement is one of the bases for the execution of operational procurement processes. So, if the S2C processes are in the wrong direction, the overall procurement performance will be affected. If the companies and organizations want to progress in the same pace with the digital revolution of the world, the processes of the tactical procurement must be automated. The automation of the tactical procurement would reduce the costs; it will increase the transparency level of spend, the contracts would be efficiently managed, the right suppliers would be taken on board, the risks of the manual processes would be mitigated, a great amount of time would be saved, the overall performance of the organization would be improved and a solid platform for the automated operational procurement would be established.

Spend management is a vital part of the strategic procurement and it is important to keep a constant and transparent track of the spend at any organization. Improper and non-transparent spend management can result in devastating consequences for any organization. As part of the strategic procurement and dependent on the operational procurement, the automation of the spend management would increase the visibility of spend, bring spend transparency, improve the supplier management, and claim management. Claim management as an integral part of the procurement should also be automated in order to have improved claim visibility, reduced claim settlement time, and reduced claim management costs. The following figure 11.1 illustrates the basic advantages of an automated spend management process over a traditional spend management process.

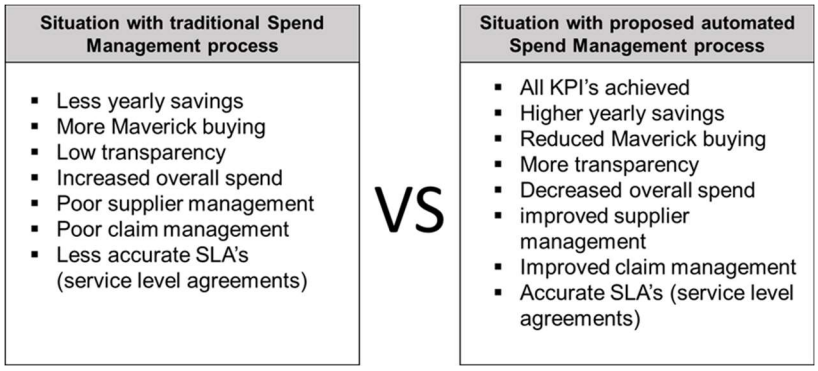


Figure.11.1. Basic difference between traditional vs automated spend management process (own content)

Poor claim management processes have always been problematic for many organizations. Claim management is an integral part of the procurement processes and if the procurement processes are correctly executed, the whole supply chain will be automatically improved which would produce better results in terms of cost savings and customer satisfaction. For accurate and improved claim management process it is important to get the P2P process automated, as this is a prerequisite to improved claim management processes.

Supplier management is also one of the most important part of the strategic procurement, it is the process to manage your suppliers properly and to achieve maximum value for your organization, it is a process of continuous improvements. An integrated and strategically focused supplier management can fix vulnerabilities and weak points in dealing with suppliers.

To select the right suppliers for any business it becomes important to correctly perform the supplier selection and evaluation process. The supplier selection process requires a great amount of the procurement financial resources, and in return, the procurement expect significant benefits from the selected suppliers. The use of Monte Carlo simulation models embedded with Weight Point Method in the supplier selection process can help the procurement to select the best suppliers out of the available and reduce the risks related to the suppliers to an extent.

An effective demand management process is the need of time in this competitive and collaborative business environment which could lead to the success of any organization. The benefits of using modern demand management should not be underestimated and the companies should invest for business sustainability in long run. Bullwhip effect is normally associated with demands, where a small fluctuation in the demand can lead to increased cost and huge reputational loss results for businesses. The automation of demand management with Monte Carlo simulation would mitigate the risks associated with demand forecasting.

The automation of procurement is the demand of time, and companies have to invest seriously in order to achieve their goals and stay long in the business, but clear objectives and measurable strategies are the foundation change in procurement. Future procurement should combine agile structures and working methods to achieve a high degree of performance for companies.

11.1 Benefits and Challenges of the Proposed Concepts

The main idea of this research is to provide concepts to automate the entire procurement process from operational until strategic level. However, the main question is, is it worth to adopt the concepts presented in this research? The concepts, which I have proposed in this research have benefits for an organization when implemented, while on the other hand there are some challenges also associated with these concepts. Figure 11.2 shows, a comparison between the benefits and challenges associated with proposed concepts in this research, which gives an opportunity to the readers to decide if the concepts are worth to be adopted or investigated further.

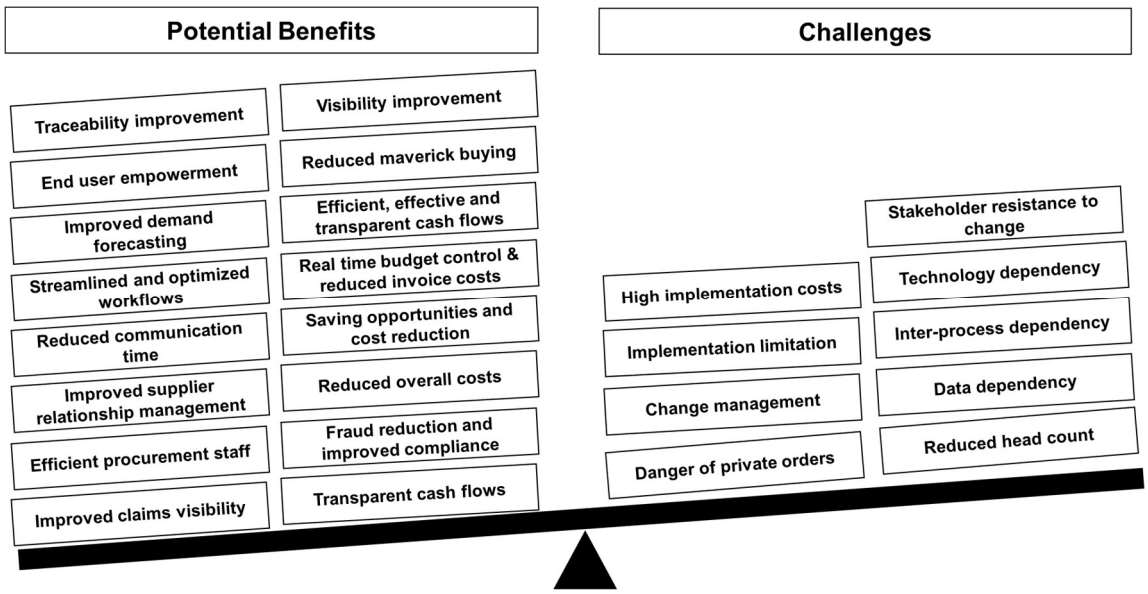


Figure.11.2. Benefits and challenges of the proposed automation concepts (own content)

11.2 Limitations of the Research

The experiments in the proposed models are performed manually and most of the analyses are done with the help of Microsoft excel. In some cases, there was no real data available, where I could test my experiments that is why I have used imaginary examples to support my experiments. This research also does not include a concept to automate the negotiations and contract management processes.

11.3 Recommendations for Future Research

This research provides a solid platform and base to any future work where someone intends to automate all the procurement processes. In this research, the concepts of Blockchain based supply chain and automation concepts for individual procurement processes are presented. As a future research to further improve these concepts, all the procurement processes should be combined, programmed, and implemented as a user-friendly software in the real world to achieve the above-proposed benefits.

The research also includes the use of Monte Carlo simulation model for the supplier selection process, which could be beneficial for future researchers, I have tried to explain on a high level how this process should work, but the future researchers should deep dive in this area to explore it more, it is worth looking into this direction.

I strongly believe that automated procurement processes in collaboration with suppliers will develop into a sustainable value driver of the industry 4.0 and will make significant contribution to the success of any company, figure 11.3 shows some recommendation levers, which could be beneficial to perform this task in the future.

Figure.11.3. Recommendation levers for future researchers (own content)

The spend management, supplier management and claim management concepts, which have been presented in this search can be combined as one concept as they are dependent on one another, and this could be a highlight for anyone who could have programming skills and wants to develop an automated reporting solution for any organization which operates in many countries. The ideal scenario would be to cover the entire procurement processes as one automated business solution for a real-world problem in a company. Any researcher who has access to the procurement data of any company can benefit from the proposed concept and can built a state-of-the-art automated solution for that company. It is expected that these recommendations may widen the concepts of this research and may contribute to the development of better-automated procurement processes.

References

Academy P (2019). Retrieved 10 07, 2019, from https://www.procurement-academy.com: https://www.procurement-academy.com/procurement-competences/operational-procurement

Accenture, DHL (2018). Blockchain in Logistics: Perspectives on the Upcoming impact of blockchain technology and use cases for the logistics industry. Troisdorf, Germany: DHL Customer Solutions & Innovation.

ACS Institute (2020). https://institute.acs.org/lab-safety. (A. Institute, Producer) Retrieved 08 16, 2021, from https://institute.acs.org/lab-safety: https://institute.acs.org/lab-safety/hazard-assessment/ways-to-conduct/what-if-analysis.html

Admin W (2012). Retrieved 8 17, 2021, from https://www.adaptalift.com.au: https://www.adaptalift.com.au/blog/2012-04-02-what-is-the-bullwhip-effect-understanding-the-concept-definition

Administration US GS (2019). Blockchain. Retrieved April 2019, from https://www.gsa.gov: https://www.gsa.gov/technology/government-it-initiatives/emerging-citizen-technology/blockchain

Aguezzoul A, Ladet P (2004). A multi-objective approach to vendor selection taking into account transportation. Second World Conference on POM and 15th Annual POM Conference, Cancun, Mexico, April 30. France.

Aleksić A, Branislav J, Stefanović M, Dapan M (2009). Risk Management Processes in Supply Chains. Retrieved from www.cqm.rs: http://www.cqm.rs/2009/3iqc/05.pdf

Amazon (2021). Retrieved 08 09, 2021, from https://aws.amazon.com: https://aws.amazon.com/what-is-cloud-computing/

amc (2017). Operational Procurement Process. Bonn: https://www.amc-group.de/. Retrieved 09 01, 2017

Anwar H (2018). Consensus Algorithms: The Root of The Blockchain Technology. Retrieved April 2019, from https://101blockchains.com: https://101blockchains.com/consensus-algorithms-blockchain/

Appel F (2012). New Models for Addressing Supply Chain and Transport Risk. World Economic Forum. Retrieved from http://www3.weforum.org/docs/WEF_SCT_RRN_NewModelsAddressingSupplyChainTransportRisk_IndustryAgenda_2012.pdf

Ashok L (2018). Zycus.com. Retrieved from https://www.zycus.com: https://www.zycus.com/blog/supplier-management/role-of-procurement-in-supplier-management-for-competitive-business-gain.html

ASQ O (2021). https://asq.org/quality-resources/fmea. Retrieved 08 11, 2021, from https://asq.org/quality-resources/fmea: https://asq.org/quality-resources/fmea

Azure M (2021). Retrieved 08 09, 2021, from https://azure.microsoft.com: https://azure.microsoft.com/en-in/overview/what-is-cloud-computing/#benefits

BBC N (2014). www.bbc.com. Retrieved 05 02, 2017, from https://www.bbc.com/news/world-europe-27497727

Beck R C, Müller B J, King L (2018). Governance in the Blockchain Economy. A Framework and Research Agenda. Journal of the Association for Information Systems (forthcoming). Retrieved 01 17, 2019, from https://aisel.aisnet.org/jais/vol19/iss10/1/

Beil D R (2009). Supplier Selection. Stephen M. Ross School of Business. Retrieved 11 10, 2021 from https://pubsonline.informs.org/doi/abs/10.1287/opre.1080.0657

Beil D R (2011). Supplier Selection. Wiley Online Library. Retrieved 22 08, 2022, from https://onlinelibrary.wiley.com/doi/full/10.1002/9780470400531.eorms0852

Belkacem, Dridi L, Hadda, Ahmed A (2020). A GIS_based multicriteria spatial decision support system model to handle health facilities resources case of crisis management in Batna, Algeria. Geographia Technica, 173-187.

Bello M, Suárez J (2003). A case study approach to the supplier selection process. Mayagüez Campus: University of Puerto Rico.

Berger P D, Gerstenfeld A, Zeng A Z (2003). How many suppliers are best? A decision-analysis approach. Omega " The international Journal of Management Sciences", Volume 32(Issue 1), Pages 9–15.

Biedron R (2018). https://www.purchasecontrol.com. (Purchase Control) Retrieved 08 12, 2019, from https://www.purchasecontrol.com/uk/blog/maverick-spending/

Bizmocom (2011). bizmocom Retrieved Retrieved 03 11, 2017 from http://www.bizmocom.dk/: http://www.bizmocom.dk/en/products/rfirfprfq.html

Bowers K (2017). The Disadvantages of Manual Document Filing Processes. Retrieved 07 07, 2021, from https://blog.mesltd.ca/the-disadvantages-of-manual-document-filing-processes

Brial P (2021). https://www.manutan.com. Retrieved 06 30, 2021, from https://www.manutan.com/blog: https://www.manutan.com/blog/en/procurement-strategy/the-six-essential-kpis-for-efficient-procurement

Brindley C (2004). Supply Chain Risk. Hampshire: Ashgate Publishing Limited. Retrieved from https://www.google.de/books/edition/Supply_Chain_Risk/YEErDwAAQBAJ?hl=en&gbpv=1&printsec=frontcover

Broadleaf (2019). http://broadleaf.com.au. Retrieved 08 20, 2021, from http://broadleaf.com.au: http://broadleaf.com.au/resource-material/bow-tie-analysis

Brown C S (2021). Retrieved 06 30, 2021, from https://www.androidauthority.com: https://www.androidauthority.com/huawei-google-android-ban-988382

Burger E, Sullivan C (2017). E-residency and blockchain. Computer Law & Security Review Volume 33, Issue 4, 470-481.

Business D (2017). http://www.businessdictionary.com. (B. Dictionary, Producer, & Business Dictionary) Retrieved 09 11, 2017, from http://www.businessdictionary.com/definition/strategic-procurement.html

Buterin V (2013). A Next-Generation Smart contract and Decentralized Application Platform. Retrieved from Ethereum/ wiki: https://github.com/ethereum/wiki/wiki/White-Paper

Buterin V (2015). Retrieved April 2019, from www.On Public and Private Blockchainsethereum.org: https://blog.ethereum.org/2015/08/07/on-public-and-private-blockchains

Buxbaum P (2017). Chinese Logistics Industry Enters Blockchain Era. Retrieved April 2019, from https://www.globaltrademag.com: https://www.globaltrademag.com/global-logistics/chinese-logistics-industry-enters-blockchain-era

Buzacott J A (1971). The Role of Inventory in Flow-line Production Systems. International Journal of Production Research, Volume 9,(Issue 4,), 425-436.

Cachin C (2016). Architecture of the Hyperledger Blockchain Fabric. Retrieved from IBM Research - Zurich: https://www.zurich.ibm.com/dccl/papers/cachin_dccl.pdf

Cale R (2018). https://medium.com. Retrieved 12 22, 2018, from https://medium.com/@caleryan/importance-of-supply-chain-management-to-our-organization-by-cale-ryan-da51bb35f6de

Carrera E (2018). https://www.springcm.com. Retrieved 05 02, 2019, from https://www.springcm.com/blog/weighing-automated-with-manual-contract-management

Carter C, Rogers D (2008). A framework of sustainable supply chain management: International Journal of Physical Distribution and Logistics Management, 360-387.

Cashwell ED, Carter L L (1975). Practical Transport Simulation with the Monte Carlo Method. Technical Information Center, Office of Public Affairs U. S. Energy Research and Development Administration.

CBR (2018). What is IoT (Internet of Things) and why does it matter? Retrieved April 12, 2019, from www.cbronline.com: https://www.cbronline.com/what-is/what-is-iot-internet-of-things-and-why-does-it-matter-4177556/

Charles D (2013). https://www.nextlevelpurchasing.com. (NLPA) Retrieved 02 03, 2018, from https://www.nextlevelpurchasing.com/articles/maverick-buying.php

Chopra S, Sodhi M (2004). Managing Risk to Avoid Supply-Chain Breakdown. MITSloan Management Review. Retrieved from https://www.researchgate.net/publication/237646139_Managing_Risk_to_Avoid_Supply-Chain_Breakdown

Christidis K, Devetsikiotis M (2016). Blockchains and Smart Contracts for the internet of things. IEEE, 2292-2303.

Christopher M, Lee H (2004). Mitigating Supply Chain Risk Through Improved Confidence. International Journal of Physical Distribution & Logistics Management, Volume 34(5), 388-396.

CIPS (2009). https://www.cips.org. Chartered Institute of Procurement & Supply, Retrieved 05 2017, from https://www.cips.org/en/knowledge/procurement-topics-and-skills/strategy-policy/procurement-strategy-development1/strategic-procurement

CIPS (2020). Retrieved 08 25, 2021, from https://www.cips.org: https://www.cips.org/knowledge/procurement-topics-and-skills/operations-management/bullwhip-effect-in-supply-chain

Claritum (2018). https://www.claritum.com. (https://www.claritum.com) Retrieved 07 07, 2021, from https://www.claritum.com/challenges-traditional-procurement-process/

Cole B (2020). Retrieved 08 17, 2021, from https://searchcompliance.techtarget.com: https://searchcompliance.techtarget.com/definition/risk-assessment

Commerce D (2017). https://www.directcommerce.com. (Direct Commerce) Retrieved 08 18, 2017, from https://www.directcommerce.com/blog/ap-automation-and-vendor-master-data/

Cranfield C (2003). Understanding Supply Chain Risk: A Self-Assessment Workbook. Department of Transport. Cranfield University School of Management - Department of transport. Retrieved from http://hdl.handle.net/1826/4373

Cranfield (2013). Classification of the Sources of Supply Chain Risk and Vulnerability. Cranfield School Of Management. Retrieved 02 01, 2016, from http://www.richardwilding.info/1/post/2013/08/the-sources-of-supply-chain-risk.html

Crosby N, Pattanayak V, Kalyanaraman (2016). Blockchain Technology: Beyond Bitcoin. Applied Innovation Review. issue no. 2. Retrieved April 12, 2019, from http://scet.berkeley.edu/wp-content/uploads/AIR-2016-Blockchain.pdf

Croxton K L, Douglas M L, García-Dastugue S J, Rogers DS (2002). The Demand Management Process. The International Journal of Logistics Management, 66.

Cummins T (2012). https://www.iaccm.com. (IACCM) Retrieved 03 03, 2018, from https://www.iaccm.com/resources/?id=6845

Cyders T (2014). https://www.slideserve.com. Retrieved 08 12, 2021, from https://www.slideserve.com: https://www.slideserve.com/gittel/failure-mode-and-effects-analysis-fmea

Daley S (2021). Retrieved 28 23, 2021, from https://builtin.com: https://builtin.com/artificial-intelligence/examples-ai-in-industry

Daniel D (2019). Tech Target. Retrieved 08 25, 2021, from https://searcherp.techtarget.com: https://searcherp.techtarget.com/definition/bullwhip-effect

Dekkers R, Sauer A, Schönung M, Schuh G (2005). Complexity based approach for collaborative enterprise networks. International Conference on Changeable, Agile, Reconfigurable and Virtual Production.

Deloach J W (2000). Enterprise-Wide Risk Management: Strategies for linking Risks and Opportunities. London: Financial Times/Prentice Hall.

Devopedia (2018). Types of blockchains. Retrieved from https://devopedia.org: https://devopedia.org/types-of-blockchains

Diaz M, Martín C, Bartolomé R (2016). State-of-the-art, challenges, and open issues in the integration of Internet of things and cloud computing. Journal of Network and Computer Applications Vol. 67, 99-117.

Dickson G W (1966). An analysis of vendor selection: systems and decisions. Journal of Purchasing, Vol.1, pp. 5–17.

Djankov S, Islam A, Saliola F (2016). How Large Is Public Procurement in Developing Countries? PIIE Peterson Institute for international economics. Retrieved 08 02, 2018, from https://www.piie.com/blogs/realtime-economic-issues-watch/how-large-public-procurement-developing-countries#:~:text=The%20World%20Trade%20Organization%20estimates,as%20in%20high%2Dincome%20ones.

Dominick C (2019). NLPA - https://www.nextlevelpurchasing.com. Retrieved 07 15, 2020, from https://www.nextlevelpurchasing.com/blog/direct-vs-indirect-spend.html

Donald C, Waters J (2007). Supply Chain Risk Management: Vulnerability and Resilience in Logistics. London. UK: Kogan Page Limited.

Dorri A, Kanhere S, Jurdak R, Gauravaram P (2017). Blockchain for IoT Security and Privacy: The Case Study of a Smart Home. IEEE International Conference on Pervasive Computing and Communications Workshops, 618-623.

Douvas S (2011). FM Global Supply Chain Risk Study: China and Natural Disasters - A case of Business Resilience. https://www.chemanager-online.com/restricted-files/173822.

Dujak D, Sajter D (2019). Blockchain Applications in Supply Chain. In A. M. Arkadiusz Kawa, SMART Supply Network (pp. 21-43). Cham: Springer.

Duteil B (2017). https://blog.ecratum.com. (Ecratum) Retrieved 07 12, 2017, from https://blog.ecratum.com/supplier-master-data-why-is-data-quality-important-for-smes

Elgabry O (2016). medium.com. (OmarElGabry's Blog) Retrieved from https://medium.com/omarelgabrys-blog/requirements-engineering-elicitation-analysis-part-5-2dd9cffafae8#targetText=Requirements%20Specification,to%20understand%2C%20

complete%20and%20consistent.&targetText=First%20iteration%20you%20specify%20the,a%20more%20

Employment B (2011). Procedure for Evaluation and Selection of suppliers. Retrieved from procurement.hubpages.com: http://procurement.hubpages.com/hub/Evaluation-and-selection-of-suppliers

Faris S (2019). https://smallbusiness.chron.com/. (Chron) Retrieved 01 13, 2020, from https://smallbusiness.chron.com/importance-contracts-business-906.html##targetText=In%20business%2C%20contracts%20are%20important,will%20be%20paid%20for%20services.

Fiala P (2005). Information sharing in supply chains. The International Journal of, 419-423.

Fisher A, Iqbal R (2019). Blockchain technology and your supply chain: a risk analysis. Retrieved April 13, 2019, from https://financialmarketsjournal.co.za: https://financialmarketsjournal.co.za/blockchain-technology-and-your-supply-chain-a-risk-analysis/

Fletcher N (2013). www.theguardian.com. Retrieved 02 02, 2018, from https://www.theguardian.com/business/marketforceslive/2013/jan/16/horse-meat-tesco-market-value-shares

Frankenfield J (2021). https://www.investopedia.com. Retrieved 08 23, 2021, from https://www.investopedia.com/terms/a/artificial-intelligence-ai.asp

Freer K (2017). https://www.corcentric.com. Retrieved 06 03, 2018, from https://www.corcentric.com/blog/the-transformative-power-of-p2p-automation/

Gabbai A (2015). Kevin Ashton Describes “the Internet of Things”. Retrieved April 16, 2019, from https://www.smithsonianmag.com/innovation/kevin-ashton-describes-the-internet-of-things-180953749/

Gartner I (2011). Supply Chain Predictions: Talent, Risk and Analytics Dominate. Stamford, USA. Retrieved 04 01, 2018, from https://www.gartner.com/doc/1853218

Gilbert F, Guggenmos F, Lockl J, Rieger A (2018). Challenges and Opportunities of Blockchain-based Platformization of Digital Identities in the Public Sector. 26th European Conference on Information Systems (ECIS).

Gillai B P, Bhat G, Sept L (2006). Innovators in Supply Chain Security: Better Security Drives Business Value. Stanford. Retrieved from https://www.researchgate.net/publication/267818712_Innovators_in_Supply_Chain_Security_Better_Security_Drives_Business_Value

Glaser F (2017). Pervasive Decentralisation of Digital Infrastructures: A Framework for Blockchain enabled System and Use Case Analysis. Proceedings of the 50th Hawaii International Conference on System Sciences.

Goh J (2018). https://publication.sipmm.edu.sg. Retrieved 08 24, 2021, from https://publication.sipmm.edu.sg: https://publication.sipmm.edu.sg/five-effective-methods-selecting-suppliers-oil-gas-industry/#:~:text=Weighted%2DPoint%20Method&text=With%20weighted%2Dpointed%20method%2C%20different,assigned%20weight%20of%20each%20factor.

Goyal M (2018). Let's get Internet of Things (IOT) ready for Procurement. Retrieved 09 11, 2018, from https://www.zycus.com: https://www.zycus.com/blog/procurement-technology/lets-get-internet-of-things-iot-ready-for-procurement.html

Grainger (2020). https://www.grainger.com. Retrieved 08 17, 2021, from https://www.grainger.com: https://www.grainger.com/know-how/business-operations/inventory-management/kh-managing-your-inventory-the-bullwhip-effect

Grassl A (2015). https://blog.esker.com. (Esker Blog) Retrieved 12 30, 2017, from https://blog.esker.com/5-benefits-of-p2p-automation/

Hale T, Moberg C, Christopher R (2005). Improving supply chain disaster preparedness: A decision process for secure site location. International Journal of Physical Distribution & Logistics Management, Vol. 35 (Iss: 3), pp.195 - 207.

Hammar M (2019). How to identify risk controls in ISO 9001:2015. Retrieved 07 12, 2020, from https://advisera.com/9001academy/blog/2019/01/21/how-to-identify-risk-controls-in-iso-90012015/

Hancock M, Vaizey E (2016). Distributed Ledger Technology: Beyond blockchain. Retrieved April 2019, from https://assets.publishing.service.gov.uk: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/492972/gs-16-1-distributed-ledger-technology.pdf

Hayes A (2019). Retrieved 10 11, 2019, from https://www.investopedia.com: https://www.investopedia.com/terms/s/scm.asp

Hergueta R F (2017). Making Blockchain Real in Transport & Logistics. Retrieved from https://www.slideshare.net: https://www.slideshare.net/roberhergueta/20170425-making-blockchainreallogistics

Hisashi A (2017). IoT Utilization in Komatsu Business. Retrieved April 12, 2019, from http://techno-forum.jogmec.go.jp: http://techno-forum.jogmec.go.jp/2017/_img/detail/ab_15_asada.pdf

Hodge K (2013). www.independent.co.uk. Retrieved 01 09, 2017, from https://www.independent.co.uk/news/uk/home-news/horsemeat-scandal-tesco-drops-burger-meat-supplier-after-breach-trust-8472183.html

IBM (2017). Maersk and IBM Unveil First Industry-Wide Cross-Border Supply Chain Solution on Blockchain. Retrieved April 13, 2019, from https://www.prnewswire.com: https://www.prnewswire.com/news-releases/maersk-and-ibm-unveil-first-industry-wide-cross-border-supply-chain-solution-on-blockchain-300418039.html

IBM (2019). IBM's Global Supply Chain Transformation Wins 2019 NextGen Supply Chain Leadership Award for Blockchain and IoT. Retrieved from https://newsroom.ibm.com: https://newsroom.ibm.com/2019-04-17-IBMs-Global-Supply-Chain-Transformation-Wins-2019-NextGen-Supply-Chain-Leadership-Award-for-Blockchain-and-IoT

Ihi (2021). http://www.ihi.org/. Retrieved 08 11, 2021, from http://www.ihi.org/: http://www.ihi.org/resources/Pages/Tools/FailureModesandEffectsAnalysisTool.aspx#:~:text=Failure%20Modes%20and%20Effects%20Analysis%20(FMEA)%20is%20a%20systematic%2C,most%20in%20need%20of%20change.

Irene B (2020). https://miro.com/blog. Retrieved 08 12, 2021, from https://miro.com/blog: https://miro.com/blog/what-is-fmea

Jaacques M (2019). Port of Rotterdam Tests Blockchain For Container Logistics. Retrieved April 2019, from https://blockchain.wtf: https://blockchain.wtf/2019/01/industry-impacts/port-of-rotterdam-tests-blockchain-for-container-logistics

Jagger (2016). https://www.jaggaer.com. Retrieved 07 20, 2018, from https://www.jaggaer.com/what-is-spend-analysis

Jansson U, Norrman A (2004). Ericsson's proactive supply chain risk management approach after a serious sub-supplier accident. International Journal of Physical Distribution & Logistics Management, Vol. 34 No. 5, 2004, 34, 434 - 456.

Johnson M (2001). Learning from Toys: Lessons in managing supply chain risk from the toy industry. California Management Review; Vol. 43(Issue 3,), p106.

Junco P (2017). Accelerating the adoption of enterprise blockchain. Retrieved April 2019, from https://azure.microsoft.com: https://azure.microsoft.com/en-us/blog/accelerating-the-adoption-of-enterprise-blockchain/

Kahneman D, Tversky A (1979). Prospect theory: an analysis of decision making under risk. Econometrica, Vol. 47 No. 2, pp. 263-91.

Kakavand H, Sevres K, Bart C (2017). The Blockchain Revolution: An Analysis of Regulation and Technology Related to Distributed Ledger Technologies. Retrieved from SSRN: https://ssrn.com/abstract=2849251

Kelly J (2015). Nine of world's biggest banks join to form blockchain partnership. Retrieved April 2019, from https://www.reuters.com: https://www.reuters.com/article/us-banks-blockchain-idUSKCN0RF24M20150915

Kenneth A W (2013). Risk Management in Global Supply Chains. Research by Case Studies of UK Companies.

Kenton W (2019). Investopedia.com. (Investopedia) Retrieved 11 27, 2019, from https://www.investopedia.com/terms/t/tender.asp#targetText=Tendering%20usually%20refers%20to%20the,response%20to%20a%20takeover%20offer.

Kerzner H (2006). Project Management: a systems approach to planning scheduling and controlling 9th ed. New Jersey: John Wiley & Sons.

Killeen A (2015). https://www.sciencedirect.com. Retrieved 11 12, 2017, from https://www.sciencedirect.com/topics/social-sciences/distributed-network.

Kinaxis (2012). Kinaxis World Headquarters. Retrieved 03 03, 2017, from http://www.kinaxis.com: http://www.kinaxis.com/whitepapers/supply-chain-risk-management.cfm

Kleindorfer P, Saad G, Germaine H (2005). Managing Disruption Risks in Supply Chains. Production and Operation Management, Vol 14(Issue: 1), 53-68.

Knut A, Strigel A (2020). Supply chain risk management is back. Retrieved 06 17, 2020, from https://www.mckinsey.com/business-functions/operations/our-insights/supply-chain-risk-management-is-back

Kunj S (2018). Arawali Supply Chain Solutions. Retrieved 08 02, 2020, from www.exportersindia.com: https://www.exportersindia.com/arawalibiotech/supply-chain-management-training-consultancy-2526987.htm

Lall V (2011). Operations Management Best Practice "Countering Supply Chain Risk". Minnesota State University, USA: QFinance " The ultimate Financial Resource".

Lansiti M, Lakhani K (2017). The Truth About Blockchain. Retrieved 01 01, 2018, from Harvard Business Review: https://hbr.org/2017/01/the-truth-about-blockchain

Lawton J (2007). http://blog.sourcinginnovation.com. Retrieved 01 12, 2017, from http://blog.sourcinginnovation.com/2007/02/14/five-types-of-supply-risk-and-how-to-mitigate-them.aspx

Layaq M W, Goudz A, Noche B, Muhammad A (2019). Blockchain Technology as a Risk Mitigation Tool in Supply Chain. International Journal of Transportation Engineering and Technology(Volume 5, Issue 3), pp. 50-59. doi:doi: 10.11648/j.ijtet.20190503.12

Layaq M W, Goudz A, Noche B, Muhammad A (2019). The impact of digitization on tactical procurement and its risk management. International Academic Journal of Procurement and Supply Chain Management, Volume 3(Issue 1), pp. 217-234.

Layaq M W, Goudz A, Noche B, Muhammad A (2019). Empowering End-User by Risk mitigation concepts in operational procurement through digitization. European Journal of Logistics, Purchasing and Supply Chain Management, pp.1-13. doi:ISSN 2054-0930 (Print), ISSN 2054-0949 (Online)

Layaq M W, Goudz A, Noche B (2020). Monte Carlo Simulation Concept for Demand Risk Identification in a Supply Chain. International Journal of Innovative Studies in Sciences and Engineering Technology (IJISSET), Volume: 6(Issue: 2).

Layaq M W, Goudz A (2020). Risk mitigation strategy for spend management in strategic procurement through automation of processes. International Journal of Supply Chain Management (IJSCM), Vol 9, No 5 (2020), 1021.

Layaq M W, Goudz A, Noche B (2020). Risk mitigation strategy to eliminate risks associated with claim management in operational procurement through automation. Journal of Supply Chain Management, Logistics and Procurement, Volume 2 (Spring 2020), pp. 211-224(14). Retrieved from https://www.henrystewartpublications.com/jscm

Lee H (2014). cyberlogitec.com. Retrieved April 15, 2019, from http://blog.cyberlogitec.com/container-terminal-management-system-internet-of-things/

Leonard J (2013). https://www.business2community.com. (Business 2 Community) Retrieved 09 12, 2019, from https://www.business2community.com/strategy/why-every-business-should-consider-purchase-to-pay-automation-part-1-0497095

Lewis A (2015). A Gentle Introduction to Blockchain Technology. Retrieved April 2019, from https://bravenewcoin.com: https://bravenewcoin.com/insights/a-gentle-introduction-to-blockchain-technology

Liao I, Lin C, Chun T (2017). A Survey of Blockchain Security Issues and Challenges. International Journal of Network Security, Vol.19, No.5, 653-659.

Lin C (2017). Operational Procurement/Purchasing. https://blog.thunderquote.com/2017/03/07/operational-procurementpurchasing/. Retrieved from https://blog.thunderquote.com/2017/03/07/operational-procurementpurchasing/

Lin L C, Liao T C (2017). A Survey of Blockchain Security Issues and Challenges. International Journal of Network Security, Vol.19, No.5, 653-659.

Linda A (2019). https://www.zycus.com/blog. (Zycus) Retrieved 09 09, 2019, from https://www.zycus.com/blog/procurement-technology/ways-to-identify-and-stop-maverick-buying.html

Lowrance W (1980). The Nature of Risk'in Schwing, RC and Albers, WA (eds.) How Safe is Safe Enough. New York. NY: Plenum Press.

Luitzen D B, Labro E, Morlacchi P (2001). A review of methods supporting supplier selection. European Journal of Purchasing & Supply Management, 75-79.

Luke P (2016). Retrieved April 2019, from https://bravenewcoin.com: https://bravenewcoin.com/insights/bank-of-america-merrill-lynch-explores-using-a-blockchain-for-trade-finance

Lung N (2007). An efficient and simple model for multiple criteria supplier selection problem. European Journal of Operational Research 186, 1059–1067. Hong Kong: Hong Kong.

Lushcheuski M (2019). Problems in achieving consensus in sustainable supply chain formation. South-Eastern Finland university of applied sciences.

Macaulay J, Buckalew L, Chung G (2015). Internet of Things in Logistics: A collaborative report by DHL and CISCO on implications and use cases for the logistic industry. Troisdorf, Germany: DHL Customer Solutions & Innovation.

Makers T D (2001). Supply Chain Risk Management. (Issue No:06/05/1).

Management S (2020). https://safetymanagement.eku.edu/blog/risk-identification/. Retrieved 08 19, 2021, from https://safetymanagement.eku.edu/blog/risk-identification/: https://safetymanagement.eku.edu/blog/risk-identification/

Mandal S (2012). https://www.semanticscholar.org. Retrieved 03 12, 2016, from https://www.semanticscholar.org: https://www.semanticscholar.org/paper/Conceptualizing-a-Model-for-Demand-Side-Risk-in-Mandal/8b92017092c459d110253700033d86990e592b21

Market Risk M (2013). Board of Governors of the Federal Reserve System. Retrieved 08 02, 2018, from http://www.federalreserve.gov/bankinforeg/topics/market_risk_mgmt.htm

Matters S (2017). http://spendmatters.com. Retrieved 06 29, 2019, from http://spendmatters.com/2017/07/20/8-benefits-procurement-technology-tools/

Mazareanu E (2021). Retrieved 06 29.06.2021, 2021, from https://www.statista.com: https://www.statista.com/topics/6350/coronavirus-impact-on-the-transportation-and-logistics-industry-worldwide/

Mckinsey C (2016). Supply Chain 4.0 – the next-generation digital supply chain. Retrieved 04 2019, from https://www.mckinsey.com: https://www.mckinsey.com/business-functions/operations/our-insights/supply-chain-40--the-next-generation-digital-supply-chain

Meinel C, Gayvoronskaya T, Schnjakin M (2018). Blockchain: Hype or Innovation. Hasso Plattner Institut Digital Engineering. Universität Potsdam.

Menoni S (2001). Chains of damages and failures in a metropolitan environment: some observations on the Kobe earthquake in 1995. Journal of Hazardous Materials, Volume 86, Issues 1–3, 101–119.

Metricstream (2011). www.metricstream.com. Retrieved 12 13, 2017, from http://www.metricstream.com/solutions/supply_chain_risk_management.htm

Microsoft (2018). how-blockchain-will-transform-modern-supply-chain. Retrieved from https://azurecomcdn.azureedge.net/cvt-fa07c1602f20d76da45dee719c203732fba17981e7a2c5f4e0a7790cfb0a4a6c/mediahandler/files/resourcefiles/how-blockchain-will-transform-modern-supply-chain/how-blockchain-will-transform-modern-supply-chain.pdf

Microtech (2017). https://www.microtech.de. Retrieved from https://www.microtech.de/erp-wiki/supply-chain-management-scm

Mishra D K, Henry S, Sekhari A, Ouzrout Y (2015). Traceability as an integral part of supply chain logistics management: an analytical review. Retrieved 08 10, 2021, from https://www.researchgate.net/figure/Complex-Supply-chain_fig1_301215211 (2015). Traceability as an integral part of supply chain logistics management: an analytical review. Retrieved 08 10, 2021, from https://www.researchgate.net/figure/Complex-Supply-chain_fig1_301215211

Monaghan C (2011). Geopolitical Risk Events and the Supply Chain. Corporate Compliance Insights. Retrieved 02 08, 2016, from http://www.corporatecomplianceinsights.com/geopolitical-risk-events-and-the-supply-chain/

Monczka T H (2005). Purchasing and Supply Chain Management "Supplier Evaluation and Selection" chapter 7. Thomson Learning.

Mossallam S (2018). The Future of Supply chain: A digitized Supply Chain. Retrieved 06 29, 2018, from https://opexsociety.org: https://opexsociety.org/body-of-knowledge/the-future-of-supply-chain-a-digitized-supply-chain/

Mougayar W, Buterin V (2016). The Business Blockchain: Promise, Practice, and Application of the Next Internet Technology. New Jersey: John Wiley & Sons.

MyInvenio (2019). https://www.my-invenio.com. Retrieved 12 03, 2019, from https://www.my-invenio.com/p2p-roi-calculator/?utm_term=%2Bbenefits%20of%20%2Bp2p&utm_campaign=%5BSEARCH%5D+Procure+to+Pay&utm_source=adwords&utm_medium=ppc&hsa_tgt=kwd-424998589641&hsa_grp=54670286338&hsa_src=g&hsa_net=adwords&hsa_mt=b&hsa_ver=3&hsa_ad=2

Nakamoto S (2008). Bitcoin open-source implementation of P2P currency. Retrieved April 2019, from http://p2pfoundation.ning.com/forum/topics/bitcoin-open-source

Nakano M (2010). A Conceptual Framework for Sustainable Manufacturing by Focusing on Risks in Supply Chains. In M. Nakano, Advances in Production Management Systems. New Challenges, New Approaches (Vol. Vol:338, pp. pp 160-167). Springer Berlin Heidelberg.

Nannore A (2014). https://www.beroeinc.com. (Beroeinc) Retrieved from https://www.beroeinc.com/whitepaper/maverick-buying/

Naughter T (2017). https://www.contractworks.com/. (Contract works) Retrieved from https://www.contractworks.com/blog/4-benefits-of-using-an-automated-contract-management-system

NextGen (2019). Announcing the 2019 Nextgen Supply Chain Award Winners. (N. S. Chain, Producer) Retrieved May 2019, from https://nextgensupplychainconference.com: https://nextgensupplychainconference.com/2019/04/announcing-the-2019-nextgen-supply-chain-award-winners/

Norris C (2020). https://medium.com/clays-thoughts/bullwhip-effects-in-an-unknown-market-cb334dd8abe4. Retrieved 08 20, 2021, from https://medium.com/clays-thoughts/bullwhip-effects-in-an-unknown-market-cb334dd8abe4: https://medium.com/clays-thoughts/bullwhip-effects-in-an-unknown-market-cb334dd8abe4

Norrman A, Lindroth B (2002). Supply Chain Risk Management: Purchasers´ vs. Planners´ Views on Sharing Capacity Investment Risks in the Telecom Industry. 11th International IPSERA conference. Enschede, The Netherlands.

Nurmaya S M (2012). Supply Chain Risk Management: Identification, Evaluation and Mitigation Techniques. Department of Management and Engineering. SE 581 83 Linköping, Sweden: Linköping University, Department of Management and Engineering.

O'Byrne R (2016). https://www.supplychainsecrets.com. Retrieved 05 13, 2018, from https://www.supplychainsecrets.com/an-introduction-to-supply-chain-collaboration/

O'Byrne R (2019). https://www.building-products.com/article/should-you-choose-a-single-or-multiple-supplier-strategy/. Retrieved 06 02, 2021, from https://www.building-products.com/article/should-you-choose-a-single-or-multiple-supplier-strategy/

Oecd (2014). OECD Foreign Bribery Report: An Analysis of the Crime of Bribery of Foreign Public Officials. Paris: OECD Publishing. Retrieved from https://www.oecd-ilibrary.org/docserver/9789264226616-en.pdf?expires=1626182349&id=id&accname=guest&checksum=CA255770829959EE5404F8932461612A

Oecd (2016). Preventing Corruption in public procurement. Retrieved from https://www.oecd.org/gov/ethics/Corruption-Public-Procurement-Brochure.pdf

Ompal, Gupta AK, Garg KR (2013). Supplier Selection Criteria and Method in Supply Chain. International Journal of Social, Human Science and Engineering, Vol.7.

Openmind BBVA (2016). Retrieved 08 23, 2021, from https://www.bbvaopenmind.com: https://www.bbvaopenmind.com/en/technology/artificial-intelligence/the-true-father-of-artificial-intelligence/

Palettesoftware (2016). https://www.palettesoftware.com. Retrieved 03 15, 2017, from https://www.palettesoftware.com/the-future-of-p2p-2

Palisade C (2013). Monte Carlo Simulation. Middlesex UK: Palisade Corporation. Retrieved from http://www.palisade.com/about/about.asp

Park Y, Hong P, Roh J (2013). Lessening the Impact of Natural Disasters on Supply Chains " Supply Chain Lessons from the Catastrophic Natural Disaster in Japan". Business Horizons; vol. 56, no. 1. Retrieved from http://www.strategy-business.com/article/re00226?pg=0

Parker L (2016). Bank of America Merrill Lynch explores using a blockchain for trade finance. Retrieved from https://bravenewcoin.com: https://bravenewcoin.com/insights/bank-of-america-merrill-lynch-explores-using-a-blockchain-for-trade-finance

Pawczuk L, Massey R, Schatsky D (2018). 2018 global blockchain survey, Breaking blockchain open. Retrieved April 2019, from https://www2.deloitte.com/content/dam/Deloitte/us/Documents/financial-services/us-fsi-2018-global-blockchain-survey-report.pdf

Pearce N (2018). https://www.hicxsolutions.com. (HICX) Retrieved from https://www.hicxsolutions.com/supplier-master-data-management-benefit-organisations/

Peck H, Christopher M (2004). Building the Resilient Supply Chain. International Journal of Logistics Management, Vol. 15, No. 2, pp1-13, 2004, 1-13.

Petersen N, Hackius M (2017). Blockchain in logistics and supply chain: Trick or treat? In T. B. Wolfgang Kersten, Digitalization in Supply Chain Management and Logistics (pp. pp.3-18). Hamburg: epubli.

Pierce F (2020). Reduce risks with technology. London: Digital Supply Chain. Retrieved 11, 02, 2011 from https://supplychaindigital.com/supply-chain-risk-management/reduce-risks-technology

Procuredesk (2019). www.procuredesk.com. (procuredesk) Retrieved Oct 12, 2019, from https://www.procuredesk.com/procure-to-pay-process-optimization/

Procurement U (2012). www.ungm.org. (P. W. (IAPWG), Producer) Retrieved Dec 11, 2019, from www.ungm.org: https://www.ungm.org/Areas/Public/pph/ch04s02.html

Puthal Puthal D, Obaidat MS, Nanda P, Prasad M, Mohanty S, Zomaya AY (2017). Secure and Sustainable Load Balancing of Edge Datacenters in Fog. IEEE Communications Magazine.

Puthal D, Malik N, Mohanty S, Kougianos E, Das G (2018). Everything You Wanted to Know About the Blockchain: Its Promise, Components, Processes, and Problems. IEEE Consumer Electronics Magazine. 7, 6-14.

Queenland (2021). https://www.business.qld.gov.au. (Q. Government, Editor) Retrieved 08 12, 2021, from https://www.business.qld.gov.au: https://www.business.qld.gov.au/running-business/protecting-business/risk-management/pprr-model

Queenland (2014). http://www.qld.gov.au. Retrieved 04 25, 2014, from http://www.qld.gov.au: http://www.business.qld.gov.au/business/running/managing-business-relationships/negotiating-successfully/negotiation-process

Queenland (2013). www.business.qld.gov.au. Retrieved 07 11, 2018, from http://www.business.qld.gov.au/business/running/risk-management/managing-risks-supply-chains/identifying-supply-chain-risks

Ray S, Puthal D, Sharma S, Mohanty P, Zomaya AY (2018). Building a Sustainable Internet of Things. EEE Consumer Electronics Magazine, 42-49.

Rendon R (2005). https://www.researchgate.net/figure/Strategic-Sourcing-Process_fig4_235180130. Retrieved from Commodity Sourcing Strategies: Supply Management in Action - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Strategic-Sourcing-Process_fig4_235180130 [accessed 17 Dec,2019]

Resilience (2019). www.resilience360.dhl.com. Retrieved 2019, from https://www.resilience360.dhl.com/about/

Reyna A, Martín C, Chen J, Soler E, Díaz M (2017). On blockchain and its integration with IoT. Challenges and opportunities. ELSEVIER.

Rich M (2014). www.theverge.com. Retrieved from https://www.theverge.com/us-world/2014/5/22/5740588/french-trains-error-sncf-too-wide-for-stations

Ritchie B, Brindley C (2007). Supply chain risk management and performance: A guiding framework for future development. International Journal of Operations & Production Management, Vol. 27(Iss. 3), 303-322.

Rodger C, Petch J (1999). Uncertainty & Risk Analysis. United Kingdom: Business Dynamics, PricewaterhouseCoopers.

Rogers P (2021). (SCM Portal) Retrieved 07 06, 2021, from https://www.scm-portal.net: https://www.scm-portal.net/glossary/maverick_purchasing.shtml

Rouse M (2012). www.techtarget.com. (Techtarget) Retrieved from https://searcherp.techtarget.com/definition/procure-to-pay-P2P

Ruijter A de, Guldenmund F (2016). The bowtie method: A review. ScienceDirect, 211-218. Retrieved from https://www.sciencedirect.com/science/article/abs/pii/S0925753516300078?via%3Dihub

SAS (2019). Retrieved 08 23, 2021, from https://www.sas.com: https://www.sas.com/en_us/insights/analytics/what-is-artificial-intelligence.html

Schweizer A, Schlatt N, Urbach V, Fridgen G (2017). Unchaining Social Businesses - Blockchain as the Basic Technology of a Crowdlending Platform. In: Proceedings of the 38th International Conference on Information Systems. Ed. by Y. J. Kim, R. Agrawal, J. K. Lee.

SCRLC (2011). Retrieved 15.02.2018, from Supply Chain Risk Management: A compilation of Best Practices. Supply Chain Risk Leadership Council. http://www.scrlc.com/articles/Supply_Chain_Risk_Management_A_Compilation_of_Best_Practices_final%5B1%5D.pdf

Sheffi Y (2005). The Resilient Enterprise. Overcoming Vulnerability for Competitive Advantage.

Shuman J, Twombly J (2008). Collaborative Network Management: An Emerging Role for Alliance Management. 313 Washington Street, Newton, MA 02458 USA: The Rhythm of Business, Inc.

Siemens (2021). Retrieved 06 20, 2021, from https://blogs.sw.siemens.com: https://blogs.sw.siemens.com/valor/2021/02/15/revolutions-are-only-visible-in-retrospect/

Sievo (2019). https://sievo.com/resources/spend-analysis-101. Retrieved 06 30, 2021, from https://sievo.com: https://sievo.com/resources/spend-analysis-101

Simon P, Hillson D, Newland K (1997). Project Risk Analysis and Management Guide. Norwich: Association for Project Management.

Simpson S W (2002). Measuring the performance of suppliers: An analysis of evaluation processes. Journal of Supply Chain Management, pp. 29-41.

Smart (2019). https://www.smartbygep.com. (GEP) Retrieved 09 21, 2020, from https://www.smartbygep.com/insight/procurement-glossary/what-is-supplier-master-data-management##targetText=Supplier%20Master%20Data%20Management%20is,records%20about%20a%20company's%20suppliers.

Smith J (2019). https://futureofsourcing.com. Retrieved 01 13, 2021, from https://futureofsourcing.com/4-ways-brexit-will-impact-your-procurement-and-sourcing-practices

Solver P R (2014). www.solver.com. Retrieved 11 13, 2018, from www.solver.com: http://www.solver.com/risk-solver-platform

Sorgi A (2020). https://www.jaggaer.com. Retrieved 06 30, 2021, from https://www.jaggaer.com/: https://www.jaggaer.com/blog/what-is-spend-analysis/

Spacey J (2017). Simplicable. (https://simplicable.com) Retrieved 11 19, 2020, from https://simplicable.com/new/requirements-risk

Spekman R, Davis E W (2004). Risky business: expanding the discussion on risk and the extended enterprise. International Journal of Physical Distribution & Logistics Management, Vol. 34(Iss: 5,), pp.414 - 433.

Steen R (2015). A risk assessment approach to support the launching of new products, services or processes. International Journal of Business continuity and risk management.

Stones M (2013). www.foodmanufacture.co.uk. Retrieved 07 07, 2021, from https://www.foodmanufacture.co.uk/Article/2013/01/30/Meat-supplier-to-blame-for-horse-meat-scandal-Tesco

Surbhi S (2017). Difference Between Risk and Uncertainty. Retrieved April 2019, from https://keydifferences.com: https://keydifferences.com/difference-between-risk-and-uncertainty.html

Svenson O (1984). Managing the Risks of the Automobile: A Study of a Swedish Car Manufacturer. Management Science, Vol. 30, No. 4, pp. 486-502.

Swan M (2015). Blockchain: Blueprint for a new economy. O'Reilly Media, Inc.

Tahriri F, Mohd R O, Ali A, Mohd Y (2008). A review of Supplier Selection Methods in Manufacturing Industries. Department of Mechanical and Manufacturing Engineering, University of Putra Malaysia.

Tapscott D, Tapscott A (2016). Blockchain Revolution, How the technology behind bitcoin is changing money, business, and the world. New York: An imprint of Penguin Random House LLC.

Taylor J (2018). https://www.basware.com. (Base Ware) Retrieved 06 11, 2019, from https://www.basware.com/en-gb/blog/february-2018/what-is-purchase-to-pay-and-why-would-you-automate/

Teeboom L (2018). https://smallbusiness.chron.com. Retrieved 07 07, 2020, from https://smallbusiness.chron.com/explain-term-supply-chain-its-importance-cost-management-69721.html

Teller C, Kotzab H, Grant D, Holweg C (2016). "The importance of key supplier relationship management in supply chains", International Journal of Retail & Distribution Management, 44, pp. 109-123. Retrieved from https://doi.org/10.1108/IJRDM-05-2015-0072

Thanaraksakul W, Phruksaphanrat B (2009). Supplier evaluation framework based on balanced scorecard with integrated corporate social responsibility perspective. Proceedings of the International MultiConference of Engineers and Computer Scientists, Vol II. Hong Kong.

Thill Y, Agarwal S (2020). Retrieved 06 30, 2021, from https://www.de.kearney.com/procurement: https://www.de.kearney.com/procurement/article?/a/covid19-batters-the-world-and-procurement

Thomson (2005). Purchasing and Supply Chain Management "Supplier Evaluation and Selection". Retrieved from facultad.bayamon.inter.edu: http://facultad.bayamon.inter.edu/jcotto/BADM%204820/WCSM%20Supplier%20Evaluation%20%26%20Selection%20Chapter%2007.pdf

Thornton P (2019). https://www.procurementleaders.com. Retrieved 03 12, 2020, from https://www.procurementleaders.com/brexit/brexit-resources/what-does-brexit-mean-for-procurement-#.Xd0Y89VKjRY

Tian F (2016). An agri-food supply chain traceability system for China based on RFID & blockchain technology. Kunming, China: IEEE.

Ustundag A, Tanyas M (2009). The impacts of Radio Frequency Identification (RFID) technology on supply chain costs. Transportation Research Part E: Logistics and Transportation Review, Volume 45, (Issue 1), Pages 29–38.

Vecchio, L. D. (2021). https://planergy.com/. (planergy, Editor, & planergy) Retrieved 10 18, 2021, from https://planergy.com/blog/tactical-purchasing/

Vitalik B (2013). Retrieved from http://blockchainlab.com: http://blockchainlab.com/pdf/Ethereum_white_paper-a_next_generation_smart_contract_and_decentralized_application_platform-vitalik-buterin.pdf

Vollmer M, Machholz K (2018). CPO Survey 2018, What's the Next Big Thing in Procurement. https://www.ariba.com. Retrieved from https://www.ariba.com/resources/library/library-pages/cpo-survey-2018

Voshmgir S (2016). Blockchain, Smart Contracts und das Dezentrale Web. Technologie Stiftung Berlin. Retrieved from https://digital.zlb.de/viewer/fulltext/16280411/1/

Wagenaarm (2018). Blockchain Decision Tree. Retrieved April 2019, from https://steemkr.com/: https://steemkr.com/blockchain/@wagenaarm/blockchain-decision-tree

Watanabe H, Fujimura S, Nakadaira A, Miyazaki Y, Akutsu A, Kishigami J (2016). Blockchain Contract: Securing a Blockchain Applied to Smart Contracts. IEEE International Conference on Consumer Electronics (ICCE'16), 467-468.

Weber CA, Current JR, Benton WC (1991). Vendor selection criteria and methods. European Journal of Operational Research, Volume 50(Issue1)2-18.

Wilkinson G (2002). An examination of the ISO 9001:2000 standard and its influence on the integration of management systems, Production.

Witte C (2017). Batch size 1 will soon cost no more than mass production. Retrieved April 2019, from https://www.hannovermesse.de/: https://www.hannovermesse.de/en/news/batch-size-1-will-soon-cost-no-more-than-mass-production-62402.xhtml

Wright A, Primavera De F (2017). Decentralized Blockchain Technology and the Rise of Lex Cryptographia. Retrieved April 2019, from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2580664

Writer S (2021). https://www.thomasnet.com. Retrieved 06 30, 2021, from https://www.thomasnet.com/insights/procurement-kpis/

Wu F, Yeniyurt S, Kim D, Cavusgil S (2006). The impact of information technology on supply chain capabilities and firm performance: A resource-based view. Industrial Marketing Management, Volume 35, (Issue 4), 493–504.

Ye L, Abe M (2012). The impacts of natural disasters on global supply chains. Bangkok: Asia-Pacific Research and Training Network on Trade. Retrieved 02 2017

Young T, Fujioka R, Yang S, Ilter H (2012). Natural Disasters and Supply Chain Management. The Journal of General Management. Retrieved from http://www.braybrooke.co.uk/CallforPapers/NaturalDisastersSupplyChainManagement/tabid/112/Default.aspx

Annexes

Annex 1 - Supplier PQQ Template

Annex 2 - 100 Critical Suppliers

Annex 3 - Evaluation Classification, Supplier Reports

DuEPublico

Duisburg-Essen Publications online

UNIVERSITÄT DUISBURG ESSEN

Offen im Denken

ub | universitäts bibliothek

Diese Dissertation wird via DuEPublico, dem Dokumenten- und Publikationsserver der Universität Duisburg-Essen, zur Verfügung gestellt und liegt auch als Print-Version vor.

DOI: 10.17185/duepublico/76954
URN: urn:nbn:de:hbz:465-20221020-105423-5

Alle Rechte vorbehalten.