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Improving Supplier Delivery Performance

Investigating Lead Time Reduction between a Bioprinter Manufacturer and a Key Supplier

Master's Thesis Project in the Master's Degree Program Quality and Operations Management

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ABSTRACT

For a fast-growing company, managing lead times efficiently is essential for acquiring market shares. When outsourcing, lead time management extends past the company's border and includes the whole supply chain and many relationship-related complications arise. Therefore, this thesis aimed to present recommendations for improving the lead time from one key supplier of the case company and also investigated problems connected to reducing lead times. In order to answer the research question, several interviews were held with the case company, the case company's supplier, and sub-suppliers. It was also crucial to map the current lead time, which was done by analyzing historical data to support the qualitative methods. The thesis presents seven recommendations to guide the case company and its supplier towards reduced lead time. The recommendations emphasized the need to take the whole supply chain into account for reaching success and how essential a functioning relationship is to achieve an efficient supply of goods.

Keywords: supplier relations, outsourcing, early supplier development, transaction cost economics, lead time reduction, communication in the supply chain.

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Petter Andersson & Amanda Wikstrand
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ABBREVIATIONS

Academy of Management (AOM)

Concurrent Engineering (CE)

Design for Manufacturing (DFM)

Early Supplier Involvement (ESI)

Enterprise Resource Planning (ERP)

Just in Time (JIT)

Key Performance Indicators (KPI)

New Product Development (NPD)

Purchase Order (PO)

Supply Chain Strategy (SCS)

Theory of Constraints (TOC)

Transaction Cost Economics (TCE)

Value Stream Mapping (VSM)

Work in Process (WIP)

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1. INTRODUCTION

During the last decades, the importance of the supply chain has increased substantially, and companies have begun to allocate more and more time and resources into developing their supply chain. One of the main issues for companies is finding suitable mechanisms to coordinate the supply chain to maintain high performance and simultaneously be as cost-effective as possible. The authors of this report had the privilege of studying a supply chain where the parties have the intention to develop a deep, long, and valuable relationship. At the same time, classical transaction costs dilemmas, and supply chain issues were present and created barriers for the awaited successful relationship. The supply chain owner in this report is a world-leading manufacturer of 3D-bioprinters, bioink, and accessories, and will, in this report, be referred to as BIOP.

High-quality but inexpensive products are required in modern markets nowadays (Battini, Faccio, Persona & Sgarbossa, 2012). For this reason, companies try to extend their supply network to maintain low costs. Organizations in the supply chains need to make trade-offs between the five performance objectives; quality, speed, dependability, flexibility, and cost, meaning that not all objectives can be maximized at the same time. However, it is essential to understand that an improvement in one part of the supply chain may adversely impact another. This report illustrates the trade-offs a life science company needs to consider when optimizing its supply chain. How does the company handle this trade-off?

1.1 TOPIC BACKGROUND

The increasing competitive forces are causing firms to critically evaluate their supply chains to manage them more efficiently (Kannan & Tan, 2006). The competitive environment is pushing firms to improve quality, delivery performance, and responsiveness while simultaneously reducing costs. Kannan and Tan (2006) state that the buyer-supplier relationship is taking on more considerable significance since firms are increasingly exploring ways to leverage their supply chains. Firms systematically evaluate the role of suppliers in their business, with one of the results being the higher outsourcing activities firms are considering. The reason behind this is that companies do not possess all necessary competencies within the firm and instead focus their activities on core competencies.

High speed, flexibility, and quality are goals and critical success factors for BIOP. As the company has grown fast, the supply chain needs to keep pace in terms of product improvements and prototyping needs. BIOP is experiencing increased demands from its customers, which entails higher volumes for its supplier. A supply chain is not only the flow of products, but it also includes the flow of information, materials, and finance in and out of an organization (Greening & Rutherford, 2011). Managing the supply chain is, consequently, an extensive activity, involving expertise from a wide range of areas. Supply chain management is defined by Christopher (2016) as the upstream and downstream management of relationships. It further involves the suppliers and customers to deliver superior customer value at less cost to the supply chain as a whole.
Supply chain management deals hence with the coordination of the supply chain, involving independently managed companies who seek to maximize their profits (Zimmer, 2002). Thus, the

overall performance of the supply chain depends on the companies' joint performance since various independent companies control it, and differences in operational goals may result in conflicts and inefficiencies for the entire chain. Transactional cost issues are also common when dealing with supply chain relationships. Every exchange of products or services in the supply chain creates a transaction, and with the transactions, several costs follow. Such as establishing and negotiating contracts, policing costs for enforcing the contracts, and costs linked to searching for alternative partners. Essentially, the more time spent on the transactions, the more expensive and less profitable they become.

BIOP has had a tremendous growth journey and, in only four years, grown from three entrepreneurs to over 200 employees. The company distributes 3D-bioprinters and substitutes to more than 50 countries, with its clients being mostly universities and research institutes using BIOP's products to develop pharmaceutical and cosmetic products. It is, therefore, necessary with strict quality control and assurance procedures to ensure consistency. The manufacturing of printers is placed in Gothenburg, and the suppliers are mainly located within the region. One of BIOP's largest supplier will in this report be called Alloy and is producing the structure of the 3D-bioprinters. BIOP has a valuable relationship with Alloy and is satisfied with Alloy as a supplier and the quality of the purchased products; however, BIOP sees improvement possibilities for the lead times. Alloy has been involved in the development of BIOP's products from the start and has, therefore, valuable information about the products and how to best produce them. It has also adapted its production specifically for BIOP's products. In this report, the possibilities for improving the lead time was investigated between BIOP and Alloy. Furthermore, Alloy's suppliers were also involved in the research; mainly, three suppliers referred to as Clean Surface, Coat, and Anode. Lead time drivers will be used as a notion in the following sections and imply factors that are significantly impacting the lead time and consequently are subject for investigation when reducing lead times.

1.2 AIM

This thesis aims to present recommendations for reducing the lead time in the supply chain by identifying possible lead time drivers. Recommendations will be proposed to target these drivers, which could reduce the lead time between BIOP and Alloy. Moreover, the thesis should evaluate closely linked factors to the lead time that will contribute to an adequate supply of goods and satisfy all parties involved. The project scope is extensive and will account for areas within production planning, supplier relationships, and interfaces in the supply chain. Hopefully, the thesis will result in a more competitive and flexible supply chain by presenting recommendations that enable shorter lead time and a more in-depth buyer-supplier relationship.

1.3 DELIMITATIONS

Due to the limited time frame, this project only investigated one of BIOP's suppliers, Alloy, along with Alloy's suppliers. Alloy was identified by BIOP as the supplier with the most extended lead times, frequent delaying disturbances, and is thereby the most interesting supplier to investigate according to BIOP. Moreover, Alloy is a significant supplier of BIOP, making the impact of the improvements from this project more meaningful.

The project will only be investigating one product ordered from Alloy, in this report called Product X. Product X is the most frequently ordered product and also the product that BIOP is experiencing as the most problematic product regarding lead times. Product X consists of 30 articles, and in this project, six of these articles have been mapped regarding historical lead time.

Furthermore, BIOP's in-house assembly and its deliveries to customers were excluded from the lead-time investigations since BIOP does not experience problems connected with this part of the lead time.

1.4 RESEARCH QUESTION

In order to facilitate the success of this project and help to reach the stated aim, one research question was formulated to guide the project.

Research Question: *How can the lead time for Product X be improved?*

This project should identify improvement areas in the supply chain that will contribute to reduced lead time. To answer the research question, it is necessary to understand the underlying factors that generate the lead time for Product X. Therefore, the lead time between Alloy and BIOP will be evaluated and answered in Chapter 4 - *Empirical Findings*. Moreover, the main drivers in lead time will be identified in the same chapter. Suggested improvements for minimizing the impact of the drivers will be presented in Chapter 6 - *Recommendations*.

2. THEORETICAL FRAMEWORK

This chapter will cover the theoretical framework used as a base in the analysis. The chapter consists of several academic areas, and the main topics are: *Supplier Relations, Supply Chain Strategies, Transaction Cost Economics, Lead Time, and Quality in the Supply Chain.*

2.1 SUPPLIER RELATIONS

Firms are extending their collaborative relationships with their supply chain partners to achieve efficiencies, flexibility, and competitive advantages (Nyaga, Whipple & Lynch, 2010). The collaborative relationships adopt a long-term approach with each supply chain partner's joint efforts to create unique value, which can not be created independently. Nyaga et al. (2010) support that firms engaged in collaborative relationships achieve improved visibility, higher service levels, increased flexibility, greater end-customer satisfaction, and reduced cycle times. Different aspects of this will be targeted in the sections below due to the importance of a satisfactory supplier relationship.

2.1.1 OUTSOURCING

Outsourcing is described as a situation known as the 'make or buy' decision (Rolstadås, Henriksen & O'Sullivan, 2012). A company can either make the product itself or buy it from an external provider. Outsourcing implies that a company chooses to divide functions or processes and outsource them to an external organization based on various reasons, for example, because they are not considered core business or too costly to perform in-house. The outsourcing decision is of strategic importance in manufacturing companies as it affects many other strategic considerations (Rolstadås et al., 2012).

Outsourcing allows firms to utilize their resources better and increase the attributable value-added connection (Kannan & Tan, 2006). Moreover, it enables firms to exploit their suppliers' capabilities, expertise, technologies, and efficiencies. Although outsourcing activities to independent, external suppliers means that the suppliers' performance is increasingly critical to the long-term success of the buying firms (Krause, Scannell, & Calantone, 2000). Suppliers have a direct impact, either positively or negatively, on many competitive dimensions, and many buying firms report a severe need for supplier improvements in quality, cost, delivery, innovation, and product design. Krause et al. (2000) highlight that suppliers' future capabilities may not meet the future needs and expectations of buying firms without interventions from the buying firm. Kannan and Tan (2006) add that outsourcing requires reliance on suppliers, and consequently, suppliers need to manage the supplier base. The management of the supply base has, for some firms implied reducing and streamlining the supplier base, while others have developed closer relationships with suppliers or both.

Outsourcing production is also risky for firms since outsourcing activities involve tacit knowledge and supplier relationships, which eventually can hurt the competitiveness of the firm (Guo, Song & Wang, 2010). The transfer of knowledge between firms involves challenges related to the tacit-explicit transfer of knowledge from individuals or team level to an organizational level (Rolstadås

et al., 2012). The transfer from tacit knowledge requires some codification of the knowledge, making it more explicit. Hence, companies need to stimulate knowledge creation while at the same time, maintain control of the knowledge creation processes.

2.1.2 PURCHASING MODELS

When developing a relationship with a supplier, it is of importance to identify which kind of relationship is most beneficial for the buying company. Several purchasing models have been developed to assist purchasers in handling their supplier portfolio (Olsen & Ellram, 1997). The models are used by assessing which kind of item is purchased, and then a strategy is suggested for the procurement of the item. Nonetheless, the models are also used to assess suppliers and decide on how to manage the relationship with them. Dubois and Pedersen (2002) discuss the benefits and drawbacks of the traditional purchasing portfolio models that aim to categorize the supplier depending on different criteria. One of the more established purchasing portfolio models is the Kraljic purchasing model, which is based on two dimensions, the purchased item's impact on profit and risks associated with supplying the item (Kraljic, 1983).

The Kraljic matrix is presented in Figure 2.1 and consists of four quadrants representing one type of purchasing item each. Simplified, each quadrant can be described as giving one distinct recommendation for the buying company, depending on the characteristics of the purchased item (Caniels & Gelderman 2005). For *Non-critical Items,* the recommendation is; ensure efficient processes, for *Bottleneck Items*; secure the flow of supply, for *Strategic Items;* establish partnerships, and for *Leverage Items;* exploit the power of wide purchasing opportunities.

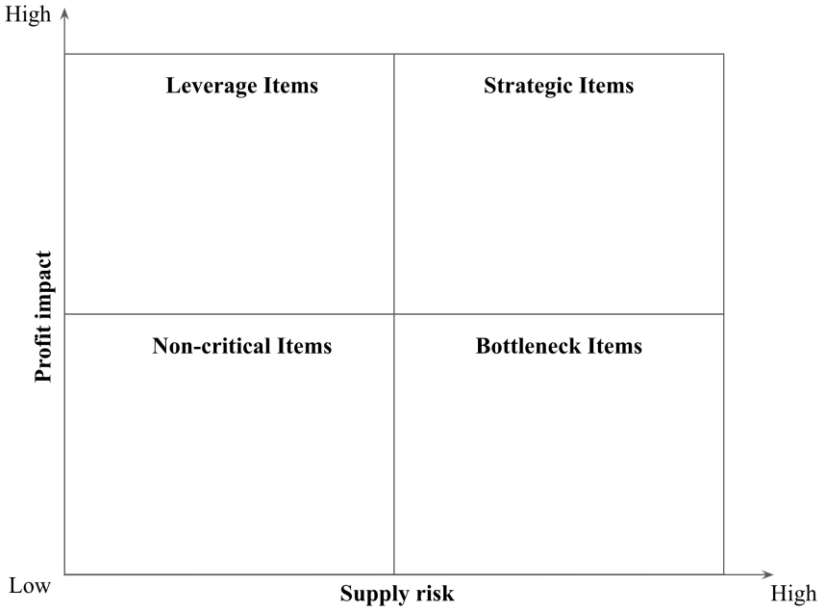

Figure 2.1: *Kraljic's purchasing model (Kraljic, 1983).*

Dubois and Pedersen (2002) argue for focusing on the network of interactions that occur between a buyer, supplier, and sub-suppliers and not only focus on the direct relationship between the buyer and the supplier. For example, a direct connection is often present between the buying company and the sub-suppliers. Focusing on these relationships and the whole network could have a more significant impact than just focusing on the two dimensions and the direct links between the

supplier and the buyer. Dubois and Pedersen (2002) also state that the existing purchasing models base around the power-dependence balance, in essence, to either exploit the power of the buyer or to avoid risks associated with being exploited by the supplier exercising power. However, a relationship often builds upon mutual counterpart-specific adjustments that will benefit both parties. A customer and a supplier need thus to be dependent on other connected relationships present in the business network, which raises possible problems with balancing the power-dependence. For example, any power advantage exploited will be costly for the counterpart.

2.1.3 NETWORKING

Networking implies that companies create partnerships and deepen their relationships while also becoming more reliant on each other, according to Hallikas, Karvonen, Pulkkinen, Virolainen & Tuominen (2004). Further, the authors argue that networking makes businesses able to respond fast to changes in the market. It raises opportunities related to critical success factors like reduced transaction costs, ability to concentrate on core skills, access to key technologies, and risk-sharing among partners. All those opportunities give direction for the development process and motives for entering into a partnership (Hallikas et al., 2004). Collaborative relations with suppliers during product development could not only allow a firm to reduce the workload, but also allow the firm to focus on core activities, take advantage of its areas of competence, and to capitalize on the supplier's competence and potential for scale economies (Takeishi, 2001).

A firm can achieve a relational competitive advantage by leveraging its knowledge assets with its supplier network (Dyer & Hatch, 2006). Hence, it may be beneficial for individual firms to share resources such as knowledge assets with a supplier network, and firms may need to collaborate closely with suppliers in technology development (Lind & Melander, 2019). Besides, direct involvement investments from a buying firm in attempts to improve a supplier's performance can, in the long-term, reduce a buying firm's transaction cost and the uncertainty regarding valuable manufacturing inputs (Krause et al., 2000). Although the investments made are not transferable, which makes it possible that the benefits and efforts from the buying company are worthless if the relationship dissolves sooner than expected. Accordingly, supplier development investments represent a risk to the buying firm (Krause et al., 2000).

2.1.4 INFORMATIONAL POWER

French and Raven (1959) introduced a concept aiming to describe how power relations can be distinguished and understood by studying the five bases of power. Those are named coercive, reward, legitimate, referent, and expert. Later on, Raven added a sixth power base, commonly known as informational power (Raven, 1965). This sixth power base is described as the power gained by possessing information that enables one party to control another party. Smaller suppliers that are dependent on a considerably larger customer often happen to find themself in an asymmetrical relationship where the supplier needs to take action in order to maintain the power balance (Siemieniako & Mitręga 2018). One method used for maintaining or reaching a more desired level of balance is to take advantage of the informational power or expert power that suppliers often possess (Siemieniako & Mitręga 2018). At the same time, power asymmetry is a standard part of a business relationship and can, if managed correctly, be beneficial for both sides

of the relationship. The coercive power source is related to using force or threats and is a separate category of the six power bases since it can be seen as less beneficial to use when the aim is a long-lasting business relationship (Siemieniako & Mitręga, 2018; Lacoste & Johnsen, 2015). Exploiting a relationship by using a coercive strategy is often interpreted as hostile even though it might not be the intention.

2.1.5 BARRIERS TO SHARING KNOWLEDGE

Several fields of study have verified the positive effects of using external knowledge for improving innovation performance (Rosell, Lakemond & Melander, 2017). Open innovation implies that New Product Development (NPD) processes need to become more open to allowing knowledge to cross a firm's boundaries. Nevertheless, Laursen and Salter (2006) suggest that openness gives rise to a paradox since the creation of innovations often requires openness, but the commercialization of innovations requires protection. Moreover, too much openness results in a decrease in performance. Besides, Knudsen and Mortensen (2011) argue for other implications with increasing openness, such as slower and more costly projects, compared to projects with less openness. This indicates that costs are involved in the knowledge transfer across firm boundaries (Rosell et al., 2017). Furthermore, network constraints, internal process rigidities, a lack of motivation, and low absorptive capacity can all be barriers to sharing knowledge (Lind & Melander, 2019).

2.1.6 OPEN-BOOK SUPPLY CHAIN

A constant dilemma when managing a buyer-supplier relationship is information sharing between them. Lamming, Caldwell, Phillips, and Harrison (2005) describe that suppliers often possess information that the customer desires. The supplier needs to handle the trade-off between sharing sensitive business information and maintaining the business relationship with the customer. The open-book supply chain theory is about sharing costs and data between the buyer and supplier to achieve a transparent relationship, where the buyer knows the supplier's costs and information to facilitate a joint development (Agndal & Nilsson, 2008). This, of course, requires a high level of trust between the supplier and the customer, and the power asymmetry is often counteracting the open book theory.

Lamming et al. (2005) argue that a one-way open-book negotiation is undesirable, which essentially means that the sharing of sensitive information only occurs from one party in the relationship. Instead, the authors propose the concept of transparency in the relationship. However, Lamming et al. (2005) state that a prerequisite is that the relationship is stable and intended for an extended period. Transparency should not be used when forming a new relationship, ending an existing relationship, or repairing a failing relationship. Furthermore, Lamming et al. (2005) explain that a power balance is needed because if only one party is sharing information, the other party is positioned in a superior position to exploit the power advantage.

2.1.7 CONCURRENT ENGINEERING AND EARLY SUPPLIER INVOLVEMENT

Concurrent Engineering (CE) and Early Supplier Involvement (ESI) are two concepts that progressively have become significant factors for successful product development (Rouibah & Caskey, 2005). CE is a method that moves the traditional sequential development process towards a simultaneous or parallel design and development process, where communication and involvement between the departments are essential (Tersine & Hummingbird, 1995). The authors further argue that the coordination between departments often is insufficient and needs to be improved in most businesses. CE works best when sharing information early in the design phase of complex product development and benefits from having all expertise available as early as possible. This expertise can advantageously be received from outside the company's border and involve both end-customers as well as suppliers. ESI becomes essential if CE is applied to a company with a high degree of outsourcing (Tersine & Hummingbird, 1995). However, since information sharing is difficult within a company's borders, it often becomes even harder to achieve a successful collaboration when it requires information transfer between companies (Rouibah & Caskey, 2005).

Boston, Culley, and McMahon (1998) state that suppliers seldom are presented with the opportunity to help their customers in the engineering design phase. The lack of information sharing between the designers and the suppliers prevents the suppliers from influencing the design. Culley (1999) presents that few companies offer standardized guidelines for how and when to communicate with their suppliers. However, the study also shows that most companies encourage supplier involvement, but since the lack of guidelines, the communication between the customer and its supplier is not occurring regularly.

2.1.8 INNOVATION IN THE SUPPLY CHAIN

The competitive business environments have increased firms' interest in the search for external sources of innovation (Yeniyurt, Henke & Yalcinkaya, 2014). Few firms possess all the capabilities and resources for developing the entire product internally, which is why such arrangements are of practical significance. Björk and Magnusson (2009) state that there is a clear interrelationship between network connectivity for individuals and the quality of the innovative ideas presented by them. Network connectivity implies the level of connections an individual has with other persons. A more connected individual has a higher chance of presenting innovative ideas. Consequently, creating a robust co-innovation environment can be a critical activity that substantially contributes to a firm's ability to maintain a competitive marketplace presence (Yeniyurt et al., 2014).

Suppliers are an essential source of innovation, and in a wide range of manufacturing industries, firms are working in a collaborative environment with their suppliers (Yeniyurt et al., 2014). According to Yeniyurt et al. (2014), the average manufacturing firm spends 50% of its revenue on suppliers. The authors further claim that external collaboration increases productivity, improves product quality and services, provides access to new markets and technologies, and cuts costs. Furthermore, supplier involvement in the buyer's NPD is beneficial for the buyer and the supplier

since it increases the performance of both parties. However, Yeniyurt et al. (2014) state that performance returns are more significant for suppliers than for buyers.

A successful co-innovation partnership requires trust between the parties. When the supplier trusts the buyer, and increased levels of information exchange are present, the result is more extensive supplier investments in buyer-specific assets (Yeniyurt et al., 2014). This can, for example, be specialized equipment to ease the production of the buyer's specific products. Supplier dependence on the buyer is another critical factor, meaning that the supplier will be more involved in the buyer's NPD process. When the dependence between them increases, terminating business agreements with that buyer has significant revenue implications. Specific investments in the relationship increase over time and thus switching partners are becoming more costly over time (Yeniyurt et al., 2014).

2.1.9 THE SUPPLIER-PARTNERING HIERARCHY

Liker and Choi (2004) state that partnerships are the lifeblood of the supply chain when the economy has evolved and become more scale-driven and technology-intensive than before. Companies, especially in developed economies, are buying more components and services from suppliers than ever before. In a study about the American and Japanese automobile industries, the authors compared the elements of Toyota's partnering model with those of Honda's. They found that although the two companies used different tools, they had many similarities. The two companies, Toyota and Honda, have built great supplier relationships by following six successive steps (Liker and Choi, 2004). At first, they create an understanding of how their suppliers work, for example, by learning about the suppliers' businesses. Second, the companies turn supplier rivalry into opportunity, which could be achieved through joint ventures with existing suppliers to transfer knowledge and maintain control. Third, they supervise their vendors by sending monthly report cards and providing immediate and constant feedback. Fourth, they develop their suppliers' technical capabilities by using a common lexicon and building suppliers' problem-solving skills. Fifth, they share information intensively but selectively and in a structured fashion. Sixth, they conduct joint improvement activities to exchange best practices with suppliers. According to Liker and Choi (2004), these six steps support each other. Therefore, the six steps are organized as a supplier-partnering hierarchy, which can be seen in Figure 2.2. The first step is the foundation of the hierarchy, and the following steps build on each other, this is to illustrate the dependence and that elements create success together.

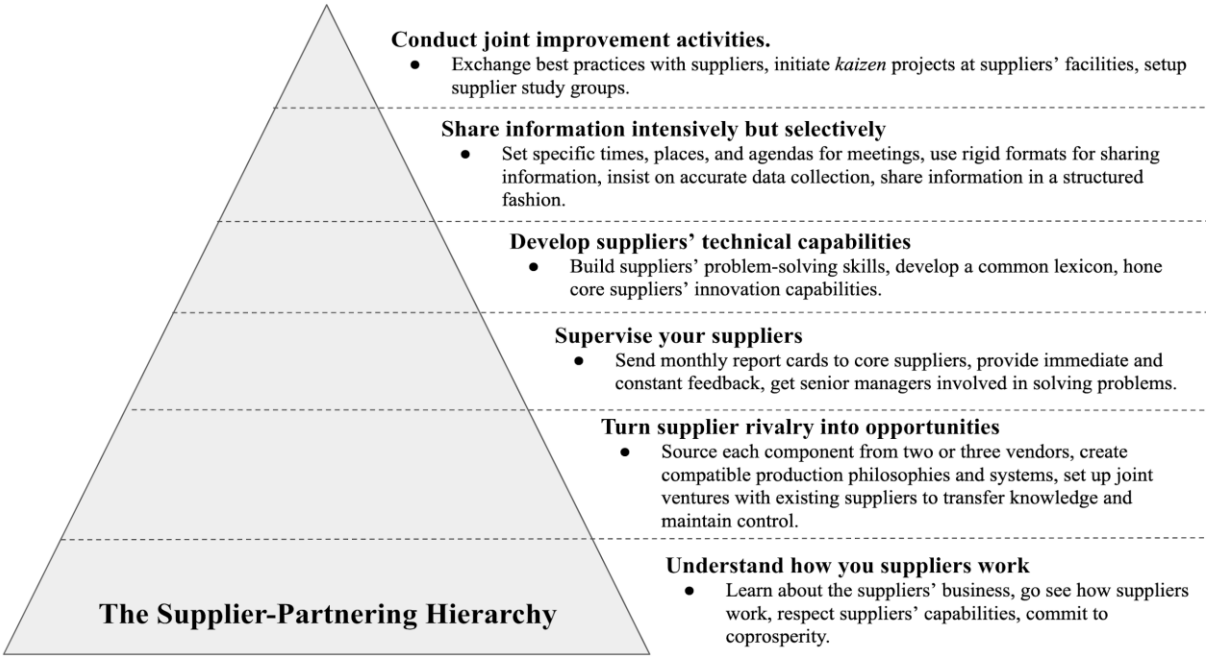

Figure 2.2: *The supplier-partnering hierarchy from Liker and Choi (2014).*

2.1.10 SUPPLIER INTERFACES IN TECHNOLOGY DEVELOPMENT

Supplier interfaces in technological development are typically characterized by a high degree of uncertainty (Lind & Melander, 2019). Developing technology is often considered an interactive process coordinated between firms, for example, a buying firm and its suppliers or customers in the supply chain. Lind and Melander (2019) suggest that firms faced with technological uncertainty prefer to rely on in-house resources rather than external sources such as suppliers. Although no firm can possess all expertise in-house and may need to rely on external sources and consequently require suppliers and supplier interfaces. Melander and Lakemond (2015) point out two possible opposite responses to uncertainty, either limiting supplier involvement or increasing the collaboration with suppliers. Limiting involvement can be beneficial for cases where safeguarding against opportunistic behaviour is needed. A higher involvement is favorable when the future is uncertain, and the relationship needs adaptability. Furthermore, higher involvement is desired when performance measurements are needed in the interfaces between the supply chain companies to monitor the agreements.

Cooper (2017) identified interfaces as one key point in reducing costs between companies. The author argues for making the interfaces more efficient by minimizing the transactional costs and reducing the uncertainty. Uncertainty can be reduced by using extended, but less frequent information, and hence replace a high number of information cycles with richer information (Cooper, 2017).

2.1.11 MOTIVATING SUPPLIERS

One way to motivate suppliers to improve continuously, and to invest in their customer relationships is to offer different kinds of incentives (Krause et al., 2000). The authors' research show that supplier incentives are an essential factor for supplier development. Suppliers can

achieve more significant improvements by motivation from their customers to continuously improve their business (Krause et al., 2000). This can, for example, be done by rewarding the supplier with increased volumes continuously when the supplier is improving, but it can also be used in the opposite direction to challenge the supplier when development is not sufficient or declining.

Another method to encourage the supplier is to challenge the supplier with other supplier alternatives and thereby increasing the competition (Krause et al., 2000). For example, involving another supplier on a trial basis shows the current supplier that it is not performing well enough and needs to make changes to keep its customer. Active involvement is another method that Krause et al. (2000) advocates. An example of active involvement is training activities that the customer provides for the supplier to develop the supplier's capabilities.

2.2 SUPPLY CHAIN STRATEGIES

There exist many different supply chain strategies to manage a supply chain. In this section, strategies connected to demand uncertainty and forecasting through a supply chain are presented. Chandak, Kumar, and Dalpati (2019) define a proper Supply Chain Strategy (SCS) as one that aligns with the organization's business strategy. Thus, managing supply chains effectively is a complex and challenging task (Lee, 2002). Due to the current business environment with trends such as expanding product variety, increasing outsourcing, and advances in information technology, successful companies need to understand how to adapt the right SCS.

2.2.1 SUPPLY CHAIN FUNCTIONS

When a company is adopting an SCS, it is recommended to examine several factors (Lee, 2002). The strategy needs to be tailored to meet specific needs for the customers, and also targeting the management of product demand. Lee (2002) remarks that a product with stable demand and a reliable source of supply should be managed differently than a product with highly unpredictable demand and an unreliable source of supply. Consequently, uncertainties in demand and supply can be used as a framework to devise the right SCS.

Marshall and Fisher (1997) noted that a supply chain that is facing demand uncertainty because of insufficient information flow has to choose between two distinct types of functions. It could either emphasize a physical function or a market mediation function. A supply chain's physical function responds to the efficient supply of goods, which is the conversion of raw materials into parts, components, and eventually finished goods, and transport from one point in the supply chain to the next. The purpose of a mediation function is to ensure the variety of products reaching the marketplace matches what consumers want to buy. Thereby, a physical function risks producing goods that did not meet customer demand, and a market mediation function risks lowering efficiencies when adjusting production to match actual demand (De Treville, Shapiro & Hameri, 2004). The choice for a supply chain, applying one of the SCSs depends solely on whether the product has a functional or innovative demand (Marshall & Fisher, 1997). Functional demand calls for a physical function since it corresponds to products that satisfy people's basic needs. Those products do not change much over time, resulting in predictable demand that could match the

supply nearly perfectly. Innovative demand calls for market mediation because it reflects innovative products that give additional reason to buy a product offering, which makes demand unpredictable. Therefore, stable and unstable products require fundamentally different SCS.

2.2.2 DEMAND- AND SUPPLY CHAIN INTEGRATION

Frohlich and Westbrook (2002) highlight integration strategies in supply chain management, which divides such integration into demand- and supply integration. Demand integration involves challenges in improving demand visibility and planning in supply chains, typically relying on information technologies and sharing data between planning and control systems to reach success. Moreover, efficient delivery and improved logistic communication are vital for demand integration. Demand-driven supply chains are the base of forecast integrations, inventory reduction, and elimination of non-value added activities. On the other hand, supply integration implies obtaining frequent, small quantity deliveries, evaluating suppliers based on quality- and delivery aspects (Frohlich & Westbrook, 2002). The focus is on long-term contracts with suppliers, which are attempting to result in lower buffer inventories and eliminate formal paperwork. Supply integration supports an efficient supply of goods, as aforementioned a physical function, and demand integration supports market mediation, with a primary role to transfer demand information to facilitate more responsiveness to changing customer needs.

2.2.3 DEMAND INFORMATION TRANSFER

A buyer in a buyer-supplier situation is usually able to either observe or adequately estimate demand before the end-consumer purchase (De Treville et al., 2004). Thereby, the availability of information that would facilitate meaningful forecasts of demand increases continuously until the exact demand is known. If an improvement of demand information is desirable, the transfer must begin with eliminating the distortions. Those distortions can arise from rationing, order batching, or price promotions that increase the bullwhip effect, which is the distortion of demand fluctuations. The distortions amplify as they move upstream in the supply chain. Full demand information transfer is attained when the actual demand information is transferred from the customer to the manufacturer with no distortion. Information transfer without distortion is a pre-request for full market mediation. A fully observed demand permits the manufacturer flexibility in scheduling or adjusting production to reflect the estimates or forecast from customer observations (De Treville et al., 2004).

In a situation when there is no demand observed, there will not be any received demand information to the manufacturer (De Treville et al., 2004). If lead times are long, this might cause the production to begin before observing demand, which may not match what the customer is demanding. A consequence is increased capacity utilization since a natural reaction is to expedite what is desired by the customer, while also finishing products in progress. The increased capacity utilization results in increased lead times, which reduces delivery performance and forces the production management to start quoting longer lead times.

2.3 QUALITY IN SUPPLY CHAIN

Quality is of importance in every business, and the quality work often exceeds outside the companies' borders. The importance of quality creates a desire to collaborate with supply chain partners to achieve a leading quality position.

2.3.1 QUALITY IN GENERAL

According to Bergman and Klefsjö (2010), there are many ways in which improved quality can lead to improved profitability, which in turn, results in remarkable leverage effects. Improved quality results in advantages regarding the success and prosperity of an organization. Shorter lead times and reduced costs due to less waste and rework are examples of positive outcomes.

Poor internal quality in manufacturing companies can cause issues in production (Bergman & Klefsjö, 2010). Therefore, high internal quality is essential since it eliminates the requirement for large buffer stocks and reserves. It is also a prerequisite for the JIT approach. As a result, a manufacturing company that works closely with logistics must also work carefully with its internal quality and the quality of its suppliers. Consequently, suppliers need to produce high-quality products for the buyers to maintain their competitiveness since it is a crucial element for success (Battini et al., 2012). Thus, firms have to strive for better visibility of the quality risks in the supply chain to minimize the quality threats for a product, such as from raw materials, manufacturing processes, or logistics operations in any tier of the supply network (Tse and Tan, 2011). The hidden risks in the supply chain increase when a firm is having an extended supply network with global multi-tiers. Tse and Tan (2011) suggest monitoring sub-tier suppliers to manage the product quality risks since the quality of a firm's product depends not only on its quality but also on their supplier's quality.

Usually, the objective of a quality inspection is to detect defects as soon as possible and formulate appropriate treatments (Battini et al., 2012). Consequently, it has become increasingly important to establish a highly capable quality assurance strategy, which aims to allocate the economically suitable level of inspection activities. Adequate quality assurance needs to set the correct mix of acceptance policies on purchased items and inspection station arrangements to minimize the production system's total quality cost.

Designing a product with the manufacturing system in mind is a crucial objective for achieving more cost-effective products and less unexpected problems during production (Marwah & Thakar, 2013). This concept is called Design for Manufacturing (DFM) and essentially suggests to consider all possible manufacturing elements during the design phase, to ease the downstream processes. DFM requires comprehensive information about the manufacturing system to design a product suited for the system (Marwah & Thakar, 2013). DFM is also suitable for achieving higher quality as the product design intends to suit the production system (Susman, 1992). The design phase is crucial when striving for optimal product quality in the supply chain because it is a critical determinant for the final product quality (Zhu, You, Alard & Schönsleben, 2009). Design specifications have a significant effect on a product's performance, quality, and cost. Zhu et al. (2009) describe that the product design phase stands for 70-80% of the final product quality, as

shown in Figure 2.3, but accounts for 75% or more of manufacturing costs. Moreover, the product design accounts for about 5% of the product cost, indicating that the design phase is considerably cheap but has a high impact on other product phases. Consequently, companies need to make the best of external resources and collaborate with their partners in the supply chain to improve their end-product quality.

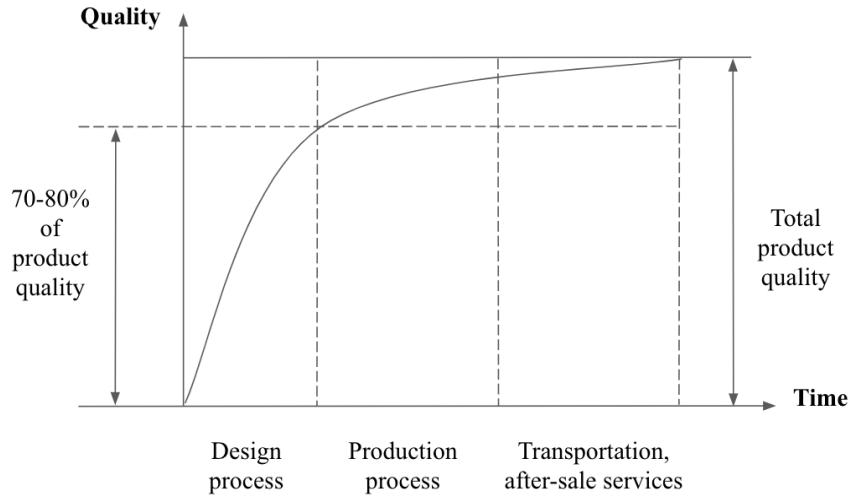

Figure 2.3: *Product phases effect on quality (Zhu et al., 2009, p.169).*

2.3.2 THE FIVE PERFORMANCE OBJECTIVES

The five performance objectives consist of objectives used to measure a firm's operational performance (Slack, Chambers & Johnston, 2007). They are as follows; quality, speed, dependability, flexibility, and cost. An organization can not excel in all factors simultaneously, and a trade-off scenario is always present (Tersine & Hummingbird, 1995; Slack et al., 2007). An organization needs to decide to focus on one or a mix of those competitive factors to gain an advantage in the market it operates. Performance in one objective might need to be sacrificed in order to improve another objective's performance. Tersine and Hummingbird (1995) present an example of a performance mix emphasized by a firm. If a firm competes on quality and lead time, it should, according to the authors, be evaluated in terms of its ability to deliver quality products in time. If other measurements are used, this could accordingly create confusion and a lack of consistency.

Effective deployment of organizational resources is of competitive importance (Tersine & Hummingbird, 1995). Therefore, it is recommended to record, monitor, and review aspects of performance to ensure that resources are allocated appropriately (Greasley, 2008). In order to rightfully assess the fulfillment of the performance objectives, the Key Performance Indicators (KPIs) need to align with the internal and external priorities. KPIs are described by Parmenter (2010) as a set of measures aiming to monitor the performance objectives most critical for the organization's success, both currently and in the future.

2.3.3 VALUE STREAM MAPPING WORK PROCEDURE

Value Stream Mapping (VSM) visualizes material and information flow of a value stream process to identify the sources of waste and enable their elimination (Andreadis, Garza-Reyes &

Kumar, 2017). It is an important technique to reduce cycle time in an existing production line (Siva et al., 2020). Furthermore, VSM is an excellent method for mapping a process more thoroughly and evaluating the value-adding time from production.

2.3.4 WASTES IN PRODUCTION

Significant improvements in production can be achieved with a low additional capital investment (Tersine & Hummingbird, 1995). Customer value is vital in order to identify what is considered value and what is waste. Everything that does not provide value to the customer can mostly be considered waste. If cost is essential, inventory is often treated as a waste, but this could also be viewed as value-adding (Tersine & Hummingbird, 1995). Since inventory and buffers counteract delays and disturbances, it enables high service levels despite frequent quality problems. A thorough understanding of the supply chain and its processes is required in order to start eliminating waste. Simplified flows in the form of a VSM is often used to connect value with the process flow and hence identify improvement areas. Any activity that does not add value but consumes time is a target for elimination, and this is a strategy known as time-based competition (Tersine & Hummingbird, 1995). Continuously improving value-adding activities to become less time consuming is an effective way of streamlining a business. Examples of threats to value-added time are; downtime, queues, and rework. Minimizing these factors will consequently also reduce the lead time within the supply chain.

2.4 TRANSACTION COST ECONOMICS

The founder of Transaction Cost Economics (TCE), Ronald Coase, established the theory behind the transaction costs. Coase (1937) argues that a transaction cost appears when a company decides to procure a product or service instead of producing it. Necessarily costs do not link directly to the product or service purchased, but instead the cost of preparing, negotiating, and handling the transaction. Coase (1937) further argues that vertical integration is the consequence of increasing transactional costs. The categorizing of transaction costs and market governance will be presented concerning the TCE theory in the following sections.

2.4.1 CATEGORIZING TRANSACTION COSTS

Alchian and Allen (1972) divide the transaction costs into three categories; search costs, bargaining costs, and policing costs. Search costs are the costs connected to the search and establishment of a proposed transaction. Bargaining costs are the costs of establishing a contract for the transaction. Policing costs are the costs of securing the compliance of the contract. The three areas all need to be targeted to lower the transaction costs, but they can never decrease to zero (Williamson, 1981). Williamson (1985) raises the contract establishment as a pillar in TCE and the area that often escalates the transaction costs. Rationality can be the reason for this since it seldom is possible to predict all possible issues that could arise. A reason for contract difficulties can also be informational power, as one party can possess useful information to exploit the flaws of the contract.

Williamson (1981) connects the rising transaction costs with three underlying sources. Firstly, the level of uncertainty in the transactions; high uncertainty implies higher transaction costs. Secondly, the frequency of recurring transactions; a high frequency creates a higher total cost since the transaction is occurring more frequently. Lastly, the investment connected to the specific transaction; a lost transaction becomes a lost investment. Therefore, it is crucial to keep the transaction. Based on the three dimensions, it is possible, according to Williamson (1981), to decide whether the transactions should occur inside or outside the company's borders. If the transactions are too expensive based on the dimensions, it is recommended by TCE integrating the transactions within the firm by, for example, an acquisition.

2.4.2 MARKET GOVERNANCE

Williamson (1985) declares that high uncertainty, combined with a small number of market partners, makes the market governance inefficient. TCE addresses the governance of activities and transactions across firm boundaries (Melander & Lakemond, 2015). Firms that are searching for collaborative NPD need to devise powerful approaches for governing the relationships with suppliers. Melander and Lakemond (2015) argue that the level of technological uncertainty in NPD is crucial to how the organization responds to transactional and relational governance. Relational governance can be seen as the governance of the social relationship between the two transaction partners (Poppo & Zenger, 2002). Projects with a higher degree of technological uncertainty need to handle the balance between transactional and relational governance. This can be done by separating the response between the R&D and purchasing department, making the R&D department work more closely, maintaining essential relationships while the purchasers continue with reducing the transactional costs. Melander and Lakemond (2005) further state that a more interactive approach is possible between the organizational departments in projects with lower uncertainty.

2.5 LEAD TIME

Supply lead time defines the time between the commitment of production and the time at which the product is available for the customer (De Treville et al., 2004). The terms confirmed lead time and actual lead time will be used in this report. The confirmed lead time corresponds to the time between the date the buyer requests the order and the date the supplier has committed to delivering the goods. Goods that are not delivered according to the confirmed delivery date will have a difference in time between the actual finished date and the confirmed finished date. This period is called the actual lead time, as illustrated in Figure 2.4. The following section focuses on the lead time in a manufacturing environment, which historically has been a problem across multiple industries (Tersine & Hummingbird, 1995). The extending lead time in manufacturing causes costly expediting and scheduling problems. Secondary problems involve extended planning horizons and increased inventories.

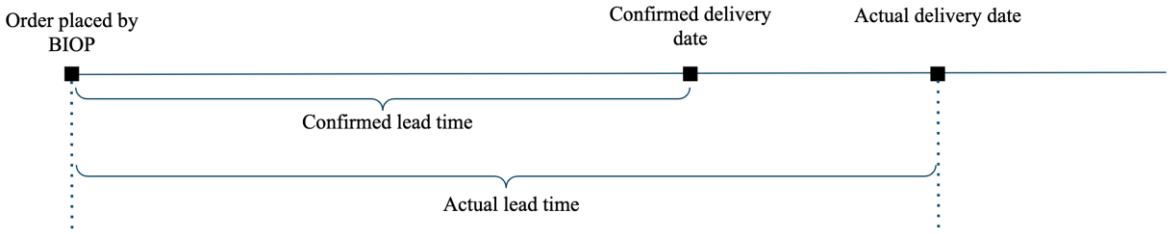

Figure 2.4: *Illustration of lead-time notions.*

2.5.1 LEAD TIME IN PRODUCTION

Manage time, specifically lead time, efficiently can be a competitive advantage for a company (Tersine & Hummingbird, 1995). Thus, it is necessary to gain control of the lead time, which requires analysis of the status quo, including the flow of material and information separated into its various elements or components. Hopp, Spearman, and Woodruff (1990) divide lead time in factory settings into the following components: run time, setup time, move time, queue time, wait for parts time, wait to move time. Furthermore, Bradt (1983) states that the time spent on different waiting activities consist of between 90-95% of the total lead time. Hopp et al. (1990) further argue for prioritizing activities focusing on minimizing queuing, waiting, and work in process (WIP). It is of importance to improve the cycle time and achieve the projected lead time in a manufacturing company to reach customer pleasure (Siva, Prabakaran, Rishikesh, Kumar & Sangeetha, 2020). Consequently, delivering the goods on time and in the correct quantity are vital factors to satisfy the customer and maintain a competitive market position.

2.5.2 LEAD TIME REDUCTION

The ultimate goal of an effective strategy for lead time reduction is not solely to cut the amount of total lead time but to decrease the throughput time (Tersine & Hummingbird, 1995). In manufacturing, throughput time is the time between the production start of an order and its completion (Johnson, 2003). A reduction of throughput time can yield numerous advantages, including lower WIP and finished goods inventory levels, improved quality, lower costs, and less forecasting error. Moreover, it increases flexibility and reduces the time required to respond to customer orders, which is especially beneficial in firms experiencing increased market pressure for shorter delivery lead times of customized products. Tersine and Hummingbird (1995) argue for starting a lead time reduction process by dividing the process into subprocesses and understanding the flow of products and information through the system. The authors further suggest a Theory of Constraints (TOC) approach to prioritizing the lead time activities. Goldratt and Cox (1984) are the pioneers of TOC, and the methodology, in summary, is an iterative method that identifies the most limiting process. This process elevates through different techniques, and when the process is satisfactorily improved, a new bottleneck will be identified.

Little's law connects WIP with inventory and lead time (Hopp et al., 1990). Increasing lead time together with increased production rate, will contribute to higher inventory. This facilitates activities aiming to control the inventory levels in order to reduce lead time in production. Moreover, Hopp et al. (1990) discuss the importance of reducing variability in production,

concentrating on minimizing rework and reclamations through more continuous quality control during the production process.

Firms that are producing products in an engineer-to-order environment start the improvement efforts with product conceptualization. This implies that the opportunity for lead time reduction begins with reducing product development times (Tersine & Hummingbird, 1995). CE is an excellent strategy for reducing product development times. Though, a comprehensive lead time reduction process involves not only the engineering stage but also to reduce lead times at all subsequent product stages. It is thus required to involve various reduction programs, such as Just in Time (JIT) and CE, covering multiple stages.

2.5.3 JUST IN TIME AS A LEAD TIME STRATEGY

JIT signifies the production and assembly of goods just in time to be delivered to the customer (Tyagi and Tewari, 2019). It is a continuous improvement philosophy and a strategy that drives lead-time reduction (Tersine & Hummingbird, 1995). Furthermore, the use of JIT strives to reach manufacturing flexibility, quick delivery time, and high productivity, along with high profitability (Tyagi and Tewari, 2019). High profitability is reached by eliminating all kinds of wastes through continuous improvement and by only producing demanded products and reducing throughput time. JIT also addressed lead time reduction in a batch flow environment, drawing attention to bottleneck resources (De Treville et al., 2004). Thus, for reducing lead times for the entire value-added chain, including the supply-side and demand-side, all bottlenecks in the system should be attacked. Thus, the aim of performing a comprehensive lead-time reduction is to locate and respond to each of these problems in the logistical chain.

When JIT deliveries are used in a supply chain, the production of the finished products largely depend on the on-time delivery of the components, since buffer inventories are typically reduced (Zimmer, 2002). The producing company and the supplier focus on eliminating inefficiencies, which will result in a situation when shortage situations are usually costlier for the producer than for the supplier. Consequently, the supplier makes less of an effort to avoid shortage situations, even though it would be optimal for the entire supply chain if the efforts were balanced.

There are several main conditions that industries need to consider before applying the JIT approach (Villa & Taurino, 2013). At first, the production sequence of products needs to be repetitive for more extended periods, so that no regular changes appear that produce significant variations in the production flow. Secondly, short setup times must be present to enable re-scheduling in short notice. Moreover, a comprehensive standardization of materials, components, equipment, and tools must be implemented to facilitate the working procedures and reduce the variation. Lastly, flexible workers are beneficial for JIT, to prevent sickness and absent personnel from disrupting the production flow. Motivation and commitment by the management are required to fulfill those conditions. Additionally, industries applying JIT must educate employees to become flexible in their positions, which is eased by a more standardized workplace.

2.5.4 SCHEDULING EFFECTS FROM LEAD TIME DELAYS

Scheduling has a primary function of all organizations and is a time and labor-intensive task (Calhoun, Deckro, Moore, Chrissis & Van Hove, 2002). It concerns the decision-making process, aiming to optimize one or more objectives in operational settings, and hence the allocation of limited resources to tasks over time. Scheduling is, therefore, fundamental to effective resource utilization by organizations. However, conditions in a dynamic environment can, and often, change due to several causes. For example, a task can take longer than planned, or workforce levels may not meet expectations. A changing environment results in uncontrollable events and re-scheduling of tasks and resources, which limit success. High WIP and other lead-time related costs are outcomes of lead time delays (Karmarkar, 1993).

3. METHODOLOGY

In this project, the research design consisted of several methods used jointly to reach the desired level of knowledge about the problem and making sure enough information was presented to solve it. The research design followed an inductive approach, and the used methods will be described in the following sections.

3.1 RESEARCH STRATEGY AND APPROACH

A research strategy is a general orientation to the conduct of business research and can be qualitative or quantitative (Bell, Bryman & Harley, 2018). Qualitative approaches are typically used to explore new phenomena and to understand individuals' thoughts, feelings, or interpretations of meaning and process (Given, 2008). The qualitative approach addresses the 'why'-questions, such as explaining why certain behaviours occur. Hence, a qualitative study is based on the researchers' interpretation of what the participants are experiencing (Bell et al., 2018). A qualitative research strategy is thus appropriate for this study due to the exploratory nature; however, quantitative data was also gathered as a compliment. Qualitative data was gathered through interviews. Moreover, quantitative data regarding orders in BIOP's Enterprise Resource Planning (ERP) system was collected. Findings from the qualitative and quantitative data are used in Chapter 4 - *Empirical Findings.*

A case study enables the researcher to gain a holistic view of a particular phenomenon or series of events (Noor, 2008). Furthermore, a case study intends to focus on a particular issue, feature, or unit of analysis, rather than a study of the entire organization. Based on this definition, the methodology of this study focused on a single case company in the biotechnology sector and its most important supplier. The research design used in this master thesis enabled the best understanding of complex real-life activities at the case company. Additionally, the method employed was in line with the intended outcome and the research problem's nature. This is also stated by Noor (2008), who proposes that a case study is especially useful when a particular problem or situation needs to be understood in-depth, and when a case is rich in information. Hence, the explorative case study approach was obtained to utilize an in-depth and detailed understanding of the problematic situation experienced, involving the case company and relevant parties in the supply chain. Moreover, the case study facilitated presumably common issues related to supplier relationships and TCE, which highly contributed to the development of recommendations aiming to overcome such issues.

3.2 RESEARCH PROCESS

Figure 3.1 below provides an overview of the research process for this project. The process consisted of three phases; a preparation phase, a data collection, and an analysis. The next sections will provide a more in-depth description of the phases.

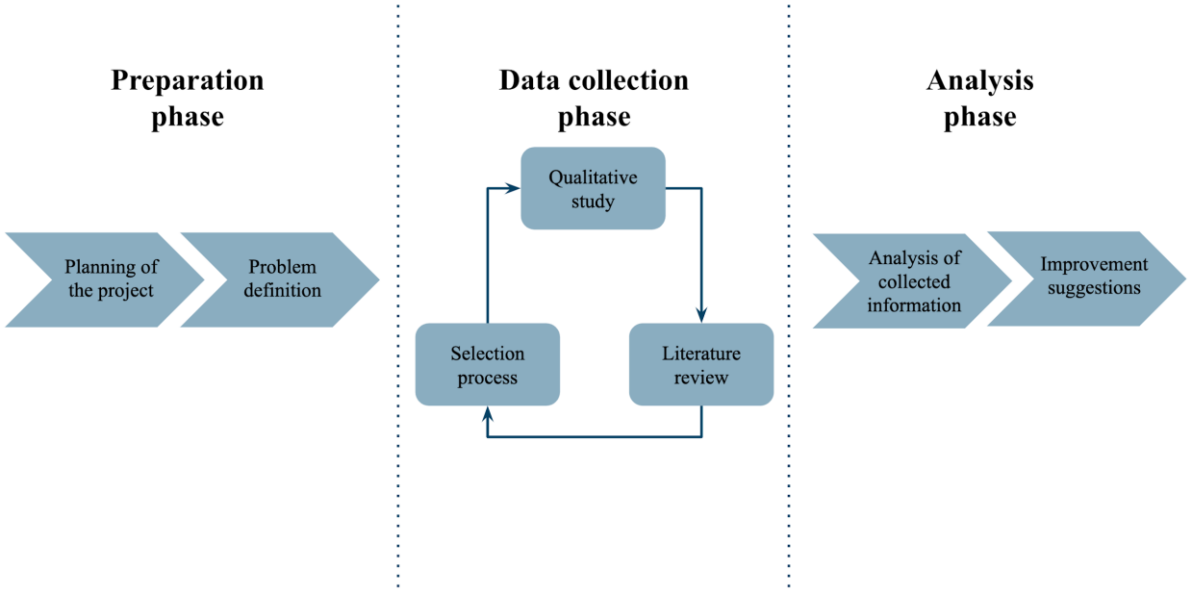

Figure 3.1: *Research process for the project.*

3.2.1 PREPARATION PHASE

In the initial phase, the aim was to understand the key objectives with the project and get an introduction to the situation investigated. Interviews were held with representatives from the case company, as well as stakeholders at its supplier, to gain a general understanding of the situation. Together with the case company, the problem was discussed, and the project's aim was decided.

3.2.2 DATA COLLECTION PHASE

The collection of data was an iterative process, which led to comprehensive empirical results. The selection process consisted of evaluating the optimal interview object to interview and which literature to review. It was an ongoing process and resulted in findings in various subjects that were investigated, including data on lead time and delivery times. Research of a qualitative character offers the particular advantage of flexibility (Ritchie, Lewis, Nicholls & Ormston, 2013). Therefore, interviews, observations, workshops, and a visual VSM could be an iterative, flexible process.

3.2.3 ANALYSIS PHASE

The last phase focused on more in-depth analysis and to develop the conclusion of the collected data in the previous step, which ended up in recommendations to the case company and its suppliers. Recommendations were written as improvements intended to be implemented at the case company and the suppliers. All recommendations were presented and discussed with involved parties, and a copy of this report was delivered to the stakeholders. The authors did not implement any improvements but instead encouraged the responsible party to do so and provide guidance.

3.3 RESEARCH METHODS

The research methods used for collecting and analyzing data in this case study consisted of several methods. Literature review, interviews, observations, and workshops aimed to obtain

accurate results and are described in the following sections. The methods described are commonly used in qualitative methods, but the execution can vary from research to research. Therefore, this section will give a more detailed view of the execution in this research project.

3.3.1 LITERATURE REVIEW

A review of relevant literature and previous research was conducted iteratively during the project to gather a variety of information used to enhance the project work. A literature review aims to identify characteristics known to impact the investigated subject (Ritchie et al., 2013). Therefore, the literature review investigated whether there have been similar projects in the past that could provide aid to this problem, and also intended to collect enough information to understand the research field. Different methods and techniques were researched to find the best practice for performing comparable tasks, for instance, 'Just in Time' and 'Value Stream Mapping.' Additionally, the review got more extensive along with the project since literature was examined consequently during the project progression based on the findings and insights from the process. These findings drove the topic selection for the literature review based on what knowledge was needed during the project's different phases.

Relevant academic articles to include in the report were generally accessed through Google Scholar and Chalmers University of Technology's online library. The search was based upon different keywords, for instance, 'supplier relationship,' 'five performance objectives,' and 'transaction cost economics.' E-books and books were also included in the literature review to reach an extensive literature review.

3.3.2 INTERVIEWS

Both individual and paired interviews were held with representatives at BIOP and its suppliers to get a shared and objective understanding of the situation. The first interviews were held with senior employees, with broad involvement in the companies, and later interviews were targeting more specific individuals with a connection to the targeted problem areas. For example, firstly, Alloy's Vice President was interviewed about the overall organization structure, and later on, department-specific personnel were interviewed about arisen topics from the first interviews.

3.3.2.1 STRUCTURE OF INTERVIEWS

The interviews during a qualitative study lean more toward an unstructured approach (Bryman & Bell, 2011). This approach provides more room for flexibility during the interviews, for example, changing the interview guide during the interview or adding follow up questions when an exciting topic is brought up. Based on this knowledge, new questions were asked during the interview, depending on what the interviewee highlighted, enabling a more in-depth analysis of the given answers (Newcomer, Hatry & Wholey, 2015). Bryman and Bell (2011) argue that it is common for multiple interviews with the same participants in qualitative interviews due to the rich and in-depth information that is sought compared to quantitative interviews. Hence, multiple interviews were held with the same employees to enable a full understanding of lead time problems.

Bryman and Bell (2011) describe unstructured interviews as interviews with a few prepared questions and only some minor topics to address. The semi-structured interviews usually consist of an interview guide with a higher level of structure and prepared questions that the interviewer plans to ask. However, the interviews might not follow the prepared path, and questions can be brought up as they appear during the conversation. All interviews during the project were categorized as semi-structured interviews, but the interviews were initially more unstructured since the sought knowledge was broad and beforehand unknown. The prior knowledge was low, and the scope of the interviews was broad, because of that, open and more unstructured interviews are to be preferred (Zhang & Wildemuth, 2009). As more information was gathered, the interviews' character was progressively becoming more structured to gain specific knowledge from the research method.

In addition to the interviews were spontaneous meetings and conversations conducted. Those arrangements can provide valuable information to the interviewees, as described by Bryman and Bell (2011). The respondent would be less likely to be affected by the researchers' expectations and hence would feel more comfortable speaking openly about highlighted topics.

3.3.2.2 INTERVIEW DESIGN

The questions asked in the first phase of interviews were founded around the research question determined for the project. The goal of the interviews was to capture as much knowledge as possible to answer the research question adequately. Significant questions were designed to provide a general understanding and confirm statements, followed by a sequence of sub-questions for further probing. Progressively as topics and problems arose during the interviews, more specific questions were added to target these problem areas and also questions to confirm previous statements by multiple sources. Bryman and Bell (2011) raise the issue of getting in contact with senior-level employees during business and management research. Since these people often have tight schedules and countless requests for interviews, the booking of such interviews regularly creates complications. This issue is something the authors of this report experienced, to some extent, throughout the project.

Creating an interview guide can be done in multiple ways. During this project, the interview guides were created by firstly identifying the aim of the interview and then designing questions to reach the goal of the interview. The interview guide mostly consisted of questions, but also of relevant broader topics to discuss. When designing the questions, the researcher tried putting themself in the position of someone who has been asked to answer the questions, as suggested by Bryman and Bell (2011). Before the interviews, the interview guide was piloted by testing the questions to confirm that the questions were understandable and targeted the right angle of the topic. Bryman and Bell (2011) argue that piloting questions clear up problems in question formulation, thus it is desirable and vital to pre-testing questions. The questions were also investigated by the researchers anticipating what the interviewees would answer to prepare counter questions and increase the involvement in the interview.

The interviews were carried out with one author asking the questions and thereby responsible for keeping the interview flow. Moreover, the other author was responsible for taking notes and

making sure all information was captured. However, both of the authors could, at times, shift the responsibilities to, for example, add a question to the interview, or the other author might add some information to the notes that were not fully captured. After every interview, a review process started where the authors analyzed the interview by correcting notes, drawing conclusions, and discussing possible improvements and learnings from the interviews. The review process contributed to the increased quality of the interviews throughout the project.

3.3.2.3 SAMPLING

The selection of interviewees followed, in the beginning, a purposive sampling strategy, indicating that members of a sample are chosen with a 'purpose' and because they have particular features or characteristics (Ritchie et al., 2013). A purposive sampling strategy will, according to the authors, enable a detailed exploration and understanding of the central themes which the researcher wishes to study. Hence, the participants selected depended on the topic to be investigated, and thus the person believed possessing most information about the topic was chosen by asking people in the organization. Additional interviews were also booked by asking current participants to recommend future participants and getting the current participant to contact exciting people for the research. The later mentioned sampling process is called snowball sampling by Bryman and Bell (2011). Employees selected for interviews during the first interview phase at the buyer company BIOP, its supplier Alloy, and sub-supplier Coat, can be seen in Table 3.1 below. The first phase intended to investigate the lead time problem with Product X and obtain a broad understanding of the supply chain.

Table 3.1: *List of employees who were interviewed during the first interview phase.*

Position	**Area of interview**	**Date**	**Time**
Head of Hardware and Purchaser at BIOP	The goal of this interview was to learn more about the problem assigned to this project. The participants were the two supervisors at BIOP during this project.	21/1-2020	180 min
Vice President at Alloy and supervisors at BIOP	Introduction meeting with Alloy. The Vice President presented the authors for key persons at Alloy and showed its facilities. The project and its purpose were briefly discussed.	28/1-2020	90 min
Purchaser and supervisor at BIOP	The interview aimed to explore the purchasing patterns at BIOP, together with the responsible purchaser for articles bought from Alloy.	29/1-2020	90 min
CEO and Production Planner at Alloy	The project was more formally introduced to Alloy, and the goal was to get to know the company and the participants of the interview. The relationship between Alloy and BIOP was the main focal point for the interview.	3/2-2020	90 min
Quality Assurance Manager at BIOP	Questions regarding the quality of Alloys products were asked, as well as the history, the current state, and possible future improvements were discussed. Also, communication regarding quality between BIOP and Alloy was a subject for this interview.	10/2-2020	60 min

Quality Controller at Alloy	Procedures during the quality check of BIOP's products were discussed, and quality issues were highlighted. Also, questions regarding reclamations were asked.	21/2-2020	60 min
CEO, Quality Manager, and Purchaser at Coat	This interview was focused on understanding the relationship between Alloy and Coat. Topics during the interview were order handling, quality issues, return patterns, etcetera.	21/2-2020	180 min
Responsible for logistics at Alloy	Alloy's booking system for transportations and its logistics with suppliers was the main focus of this interview.	2/3-2020	60 min

When enough information was collected about Product X and its connected problems, further topics were investigated in a second interview phase, as described in Table 3.2. The topics covered during these interviews were mainly about the prototype process and batch size decisions at Alloy. Those topics intended to attain knowledge about the parties' collaboration during NPD, and thus reveal information about ESI and technical innovation.

Table 3.2: *List of employees who were interviewed during the second interview phase.*

Position	**Area of interview**	**Date**	**Time**
Head of Hardware at BIOP	Interview to understand the prototype production collaboration between BIOP and Alloy. Focus on the process steps as well as the communication both internally at BIOP and with Alloy.	16/3-2020	60 min
Responsible for logistics at Alloy	Detailed questions regarding the process for pre-booking were asked. Batch sizes and delivery precision were other subjects that were dealt with.	17/3-2020	60 min
Production Planner at Alloy	The interview aimed to understand how the batch sizes are decided and which factors are evaluated in the calculation. Questions about the flow of prototypes and JIT was also asked.	19/3-2020	30 min
Vice President at Alloy	The interview targeted prototype production and communication with BIOP. Moreover, targeting areas was how the process is structured to handle prototypes at Alloy and responsible for these steps.	25/3-2020	160 min

3.3.3 OBSERVATIONS

Observations are advantageous to gather the information that the participants do not think of telling during an interview and could, therefore, be a strong complement to the interviews (Patton, 2002). Further, face-to-face meetings are more common and appropriate when conducting qualitative research in business than phone-interviews that are more common for market surveys (Bryman & Bell, 2011). Hence, the research team spent a substantial amount of time performing interviews face-to-face at both BIOP and Alloy to get a broad understanding of how the two companies work. Bryman and Bell (2011) argue that interviewees can notice gestures and expressions when they are physically present, which could affect and have an impact on the interview. Observations were

also performed when evaluating both Alloy's and BIOP's organizations, for example, during the quality inspections. The procedures used at BIOP were observed and compared with Alloy's procedure to see how well the chosen quality standard was communicated and applied.

3.3.4 WORKSHOPS

A workshop is a collaborative working session where a team achieves an agreed goal jointly (Hamilton, 2016). In this study, workshops were held with different objectives, such as to create ideas and collect information about a problem or work through an issue. The workshops used a structured creative approach and had different forms of agenda and behaviors than regular meetings and interviews. The reason was that quantitative data aimed to be collected through the workshops. During the workshops, a more collaborative approach was used and often aimed to collect information together with the participant. Examples of workshops can be seen in Table 3.3, including details about the participants.

Table 3.3: *List of employees who were participating in the workshops with various topics for further investigation.*

Participants	**Description**	**Date**	**Time**
Purchaser at BIOP	At this workshop, historical deliveries from Alloy to BIOP were studied to find specific order and products to investigate further.	10/2-2020	120 min
CEO at Alloy	Further investigations about deliveries and the detection of possible problems historically were executed during this occasion.	13/2-2020	200 min
CEO at Alloy	A visual VSM was performed, following a specific product through Alloy's production and mapping process times and batch sizes.	26/2-2020	180 min
Purchaser at BIOP	The goal at this stage was to get data from all the deliveries concerning Alloy during 2018, 2019, and 2020, to measure delivery precision and discover patterns in deviations. This was done with access to BIOP's ERP system.	4/3-2020	90 min
Purchaser at BIOP	The mapping of delivery precision between Alloy and BIOP was continued. Specific issues with the data were discussed, and supplementary information was recovered to obtain a satisfactory result.	10/3-2020	60 min

3.3.4.1 VALUE STREAM MAPPING

A visual VSM was performed at BIOP's supplier Alloy to visualize a component's process in the production and reveal possible sources of waste to eliminate. The activity was limited to the door-to-door production but also involved suppliers, from when raw material was delivered until the products were shipped to BIOP. VSM is the basis on which other streamlining activities are implemented, and it is one of the best visual tools to map a process and eliminate its critical issues (Carmignani, 2017). The activities demand to focus on minimizing non-value-adding activities to

improve an organization's overall productivity and efficiency, and consequently create more value for its customers (Andreadis et al., 2017).

The goal of creating a VSM is first to map the current process and visualize the process by creating a current state map (Rother & Shook, 2003). This map is then used to develop a future state map where unnecessary wastes are reduced, and the future state map represents a more efficient state of the mapped processes and a goal for the improvement team. This procedure was used as a basis when the VSM was created during this project. The researchers in this project were forced to deviate from the initial plan since Alloy did not allow the authors to map all processes in detail. Because of limitations in the information sharing, it was impossible to execute some of the steps, and a more high-level approach was used.

3.4 RESEARCH QUALITY

How to assess the quality of qualitative research has widely been discussed, and several methods have been presented (Bryman & Bell, 2011). The authors discuss an alternative method to the more traditional methods, which are based on reliability, validity, and more established quantitative research studies. The suggested method consists of two areas, trustworthiness and authenticity, and originated in Lincoln and Guba (1985).

3.4.1 TRUSTWORTHINESS

Bryman and Bell (2011) arrange trustworthiness into four criteria correlated with the traditional qualitative assessment method of validity and reliability; *credibility, transferability, dependability*, and *confirmability*.

Credibility refers to in which degree the findings are considered to be believable. Several measures were taken to achieve credibility. During the research, triangulation and respondent validation have been used to ensure the quality and correctness of the collected information. To ensure that the information provided from each interview was understood correctly, both authors were always present. Thus, the risk of misinterpreting the answers or missing any valuable information could be mitigated.

Transferability, also known as generalisability, is described by Ritchie et al. (2013) as the ability to transfer knowledge from the sample to the rest of the population. Due to the nature of the research, the population can be seen as the company and suppliers involved in the study. The restricted number of people working with these questions makes the sample close to the actual population.

Dependability is, according to Bryman and Bell (2011), the ability to follow the research process and receive explanations for the decisions made during the research phases. Using an audit approach is suggested, and during this project, the authors have reviewed the process and identified gaps in the research process and consequently corrected the issues to make the process traceable.

Confirmability means showing that the research has been performed for the correct purposes, and no personal opinion or other parties have impacted the research. The goal is an objective outcome

of the research. During the research, the process and the methods used have been reviewed and controlled by other parties, ensuring the research's confirmability.

3.4.2 AUTHENTICITY

Furthermore, Bryman and Bell (2011) divide authenticity into five categories; *fairness, ontological authenticity, educative authenticity, catalytic authenticity*, and *tactical authenticity*. The criteria of authenticity are directed towards the goals of the research and justifying the research and its methods.

Fairness is the first part of authenticity and aims to make sure the research participants and the social setting is correctly reflected. All stakeholders of the research should be represented and involved in the research to create a nuanced view. Fairness has been considered through this master thesis, and the authors aimed to involve all stakeholders, however, not all stakeholders were equally accessible.

Ontological authenticity aims to ensure that the participants arrive at an improved perception of the studied environment. The results have educated the participants in the researched area and improved their perception of the studied environment.

Educative authenticity implies that the study should educate the participants about the social settings of other people and to understand them better. This authenticity had a significant role in the research since it educated all supply chain partners about the others' perceptions and contributed to a more mutual understanding of the collaborations.

Catalytic authenticity is questioning if the research can contribute with motivation for the participants to change their social settings and environment. The result gave distinct information about the current situation, which contributed to the parties' motivation to improve.

Tactical authenticity is whether the research has made it possible for the population to engage and take action to develop their surroundings. The recommendations presented attended to provide a clear path for the participants to improve their surroundings and develop them in the researched area.

3.5 RESEARCH ETHICS

When executing a research project of a qualitative character, it is essential to consider the ethical aspects. Orb, Eisenhauer, and Wynaden (2000) present beneficence as one crucial element, which implies that the research is supposed to do good and prevent harm to the participants. This aspect has been acknowledged by carefully evaluated the possibility of harm to the research participants and how it should be minimized. During this project, the goal was to help the owner of this project, BIOP, as well as its supplier, Alloy, to become more competitive. This project was hence beneficial for both companies as well as their employees because they were presented with possible improvements to their business. Since all improvements require changes, the work done during this project could harm specific individuals, but the severity of the negative impact was perceived as low. It was always crucial that the project leaders had this in mind and weighed the pros and cons of every decision towards the impact it would have on the employees and others involved.

Bryman and Bell (2011) state that the usage of the Academy of Management (AOM) Code of Ethical Conduct recommends that issues relating to confidentiality and anonymity should be negotiated and agreed with potential research participants. Additionally, if confidentiality or anonymity is requested, this must be honored. Ethical principles were considered during all contact with the companies, and interview objectives were kept anonymous. However, their role in the company is described since it was considered to bring value and understanding of the context. Before the publication of this report, all involved companies were contacted to ensure that the organizations agreed on the findings and the data collected. The companies also controlled the anonymity to guarantee that the organizations were not identifiable through the report.

Furthermore, the Code of Ethical was taken into consideration by explaining the purpose of this project in every initial contact with a new individual to the interviewee, followed by advantages for the involved parties. The theme and purpose of every interview were also presented. Hence, responsibility has been taken to follow this code and take consistent precautions.

4. EMPIRICAL FINDINGS

In this chapter, the findings from the empirical study are presented, mainly based on interviews and workshops at the case company BIOP and its supplier, Alloy.

4.1 INTRODUCTION TO THE SUPPLY CHAIN

BIOP is, as mentioned earlier in this report, the supply chain's buying company and, accordingly, the supply chain owner. Alloy is a first-tier supplier and has an essential role in BIOP's products. Alloy is the supplier for the examined product investigated in this project, Product X. Other parties active in the supply chain for Product X are Alloy's suppliers, consequently BIOP's sub-suppliers. Alloy's leading suppliers, and the ones involved in this research, are referred to as Clean Surface, Coat, and Anode. Clean Surface performs the surface treatments of articles to Product X, Coat is coating the articles, and Anode executes anodizing for some of the articles. The supply chain hierarchy can be seen in Figure 4.1 below.

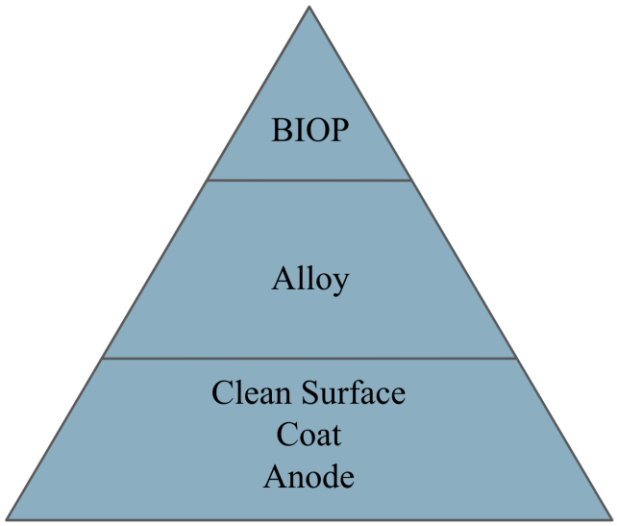

Figure 4.1: *A model of the supply chain hierarchy.*

4.1.1 ALLOY

Alloy is a small production company located in the Gothenburg region. It employs over 20 persons and has a long history in the industry. Alloy is a complete mechanical producer, offering a wide range of services and focuses on high-quality products for demanding clients. Alloy has around 30% of its revenue from BIOP and is consequently an important customer for Alloy.

4.1.2 PRODUCT X

As stated previously in this report, the report focuses on one product delivered from Alloy, called Product X. When finally assembled, Product X corresponds to a 3D-bioprinter used in, for example, laboratories and research institutes. Alloy is producing the metal construction and mechanical parts for the 3D-bioprinter. The product consists of almost 30 articles that form one Product X. BIOP usually orders larger batches of Product X, for example, 100 products. This order is divided into kits of ten products and shipped weekly for ten weeks, as illustrated in Figure 4.2.

As can be seen, the lead time is the time from when BIOP is placing an order at Alloy until the first ten products are delivered. After the first delivery, ten products are expected for the following weeks until the total quantity is reached.

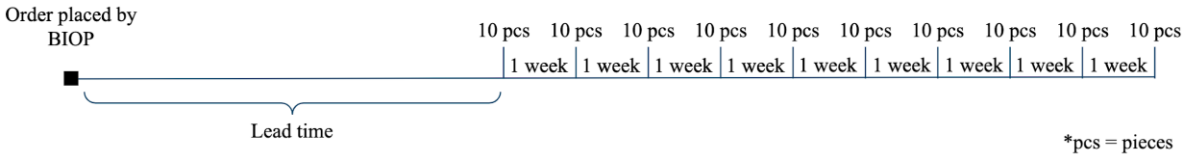

Figure 4.2: *Delivery schedule for Product X from Alloy to BIOP.*

4.2 CURRENT PROCESS FLOW

The process associated with the production of articles to Product X will be explained in this section. The process flow is not always straightforward and can thus take many possible directions depending on if problems in, for example, quality are detected along the way. In line with the report's aim, the process flow is described to make a clear visualization of the interfaces included in the process. Figure 4.3 shows the relationship in the supply chain between the parties for this study.

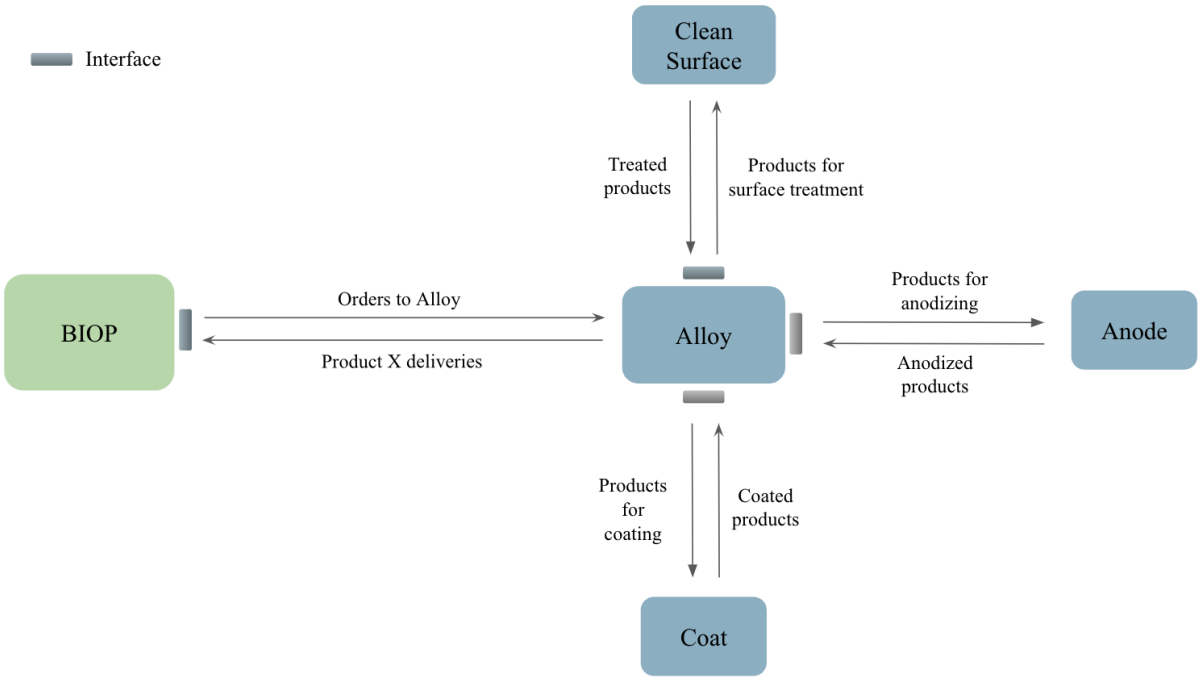

Figure 4.3: *BIOP's relationship and process flow with suppliers, including interfaces.*

The process begins at BIOP, where customer demand for Product X is initiated. BIOP's purchasing department receives order demands and sends a Purchase Order (PO) to Alloy for production. The production of Product X includes three external processes used by Alloy. Clean Surface, Coat, and Anode operate these three processes. Clean Surface receives articles from Alloy and has a vital role in treating the surface of the articles before the coating of the articles. Some of the articles are also sent to Anode for anodizing. Coat executes the coating of all articles. After coating, the products are sent back to Alloy for a final check and then sent to BIOP's location for assembly.

One of the articles included in Product X is article A. This article has received extra attention throughout the project since the qualitative data showed indication on long lead times and late deliveries. The article has a history of frequent delays and recurring quality issues. The process flow for article A can be seen in Figure 4.4. The article consists of several sub-articles with different process steps, but the overall process can be simplified as in the figure below. The first step is laser cutting, where sheet metal is cut in a machine into appropriate dimensions. After that, the sheet metal is deburred before it is bent into the correct shape. Alloy's production consists of three different production facilities, and therefore the following step is internal transportation between two facilities. At this location, the sub-articles are welded together into article A. The next step is a sequence of transportation to the external suppliers, Clean Surface, and Coat, where the article is first surface treated and then coated. Finally, the article arrives back at Alloy's third facility, where a final check is done before the article is shipped to BIOP's assembly facility.

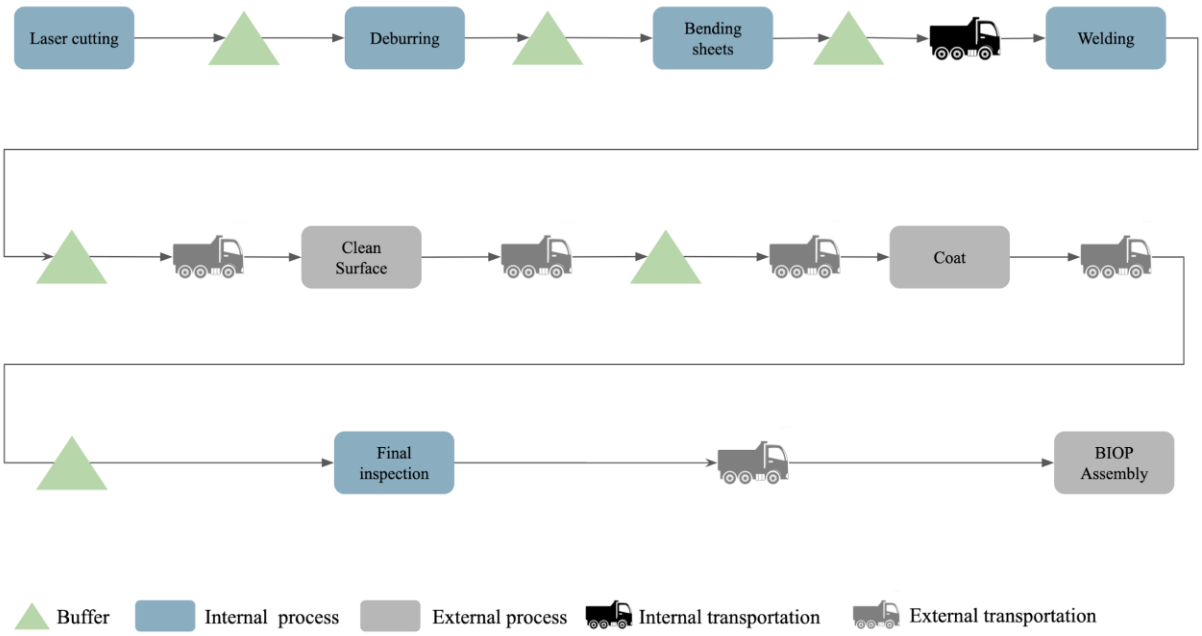

Figure 4.4: *Process flow for article A.*

4.3 LEAD TIME

In order to answer the research question, the current lead time for BIOP's orders at Alloy needed to be measured. Lead time is in this project defined as the time from an order is placed at Alloy until the products are delivered to BIOP. The total lead time experienced by BIOP is based on the article that has the longest throughput time internally at Alloy; this is visualized in Figure 4.5. Consequently, the article with the longest lead time is the lead time driver, and hence the bottleneck. It can also be seen that administration time is a part of the lead time; this will be elaborated on later in this chapter.

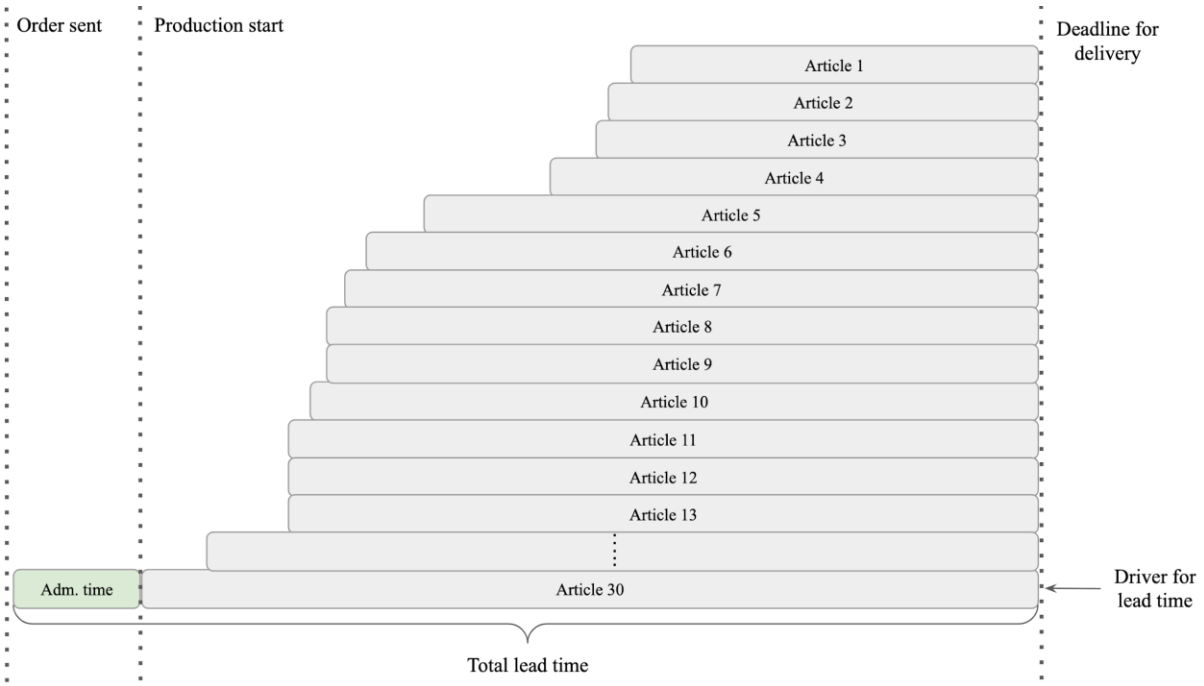

Figure 4.5: *Lead time example of Product X.*

Based on historical data from BIOP's ERP-system, it was determined that the confirmed lead time varied between 8-10 weeks during the year of 2019. The distribution of the confirmed lead time during 2019 can be seen in Figure 4.6. The POs are arranged in historical order, and worth noticing is that the confirmed lead time has increased during the year, from around 8 to 10 weeks. Some POs have been excluded from this chart since they were either special deliveries or because BIOP made two orders simultaneously, with one order following directly after the other. In these cases, the second order received an unrepresentable lead time and was not relevant for this case. Every PO includes several deliveries, and the numbers presented for each PO is an average for all included deliveries. The research has also revealed that the actual lead time often is far longer; this can be seen in Figure 4.6. A comparison shows that all orders have been late except for PO836 and that the other POs are at least two weeks late. Alloy has admitted to accepting too optimistic lead times early in 2019, and then continuously increased them since it could not be achieved.

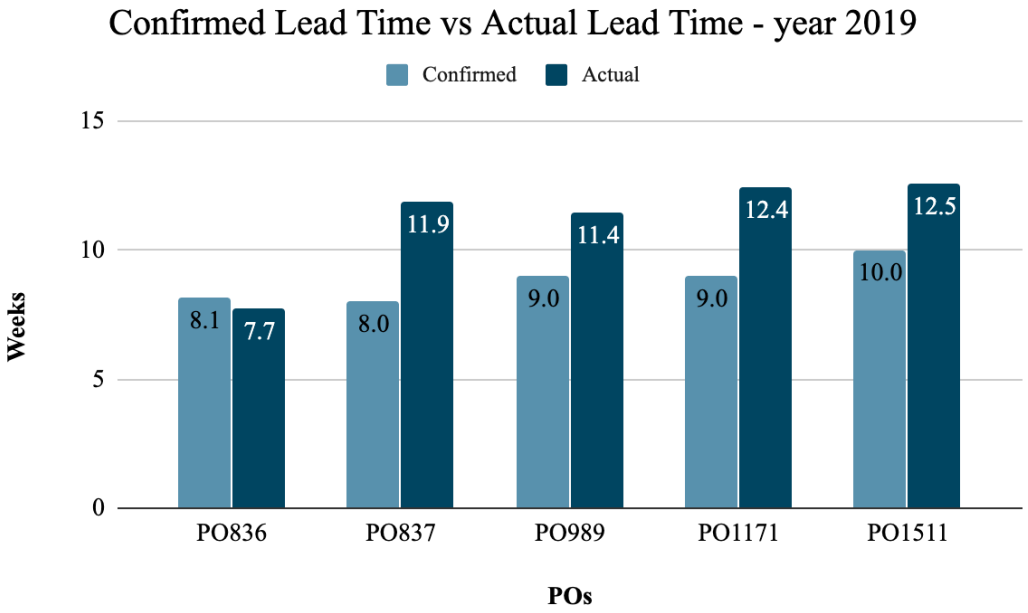

Figure 4.6: *Confirmed lead time vs actual lead time for Product X during 2019.*

The confirmed lead time includes the time it takes until Alloy confirms an order. Thus, it is interesting to find out how much lead time is assigned to confirm the orders. The number of days, including weekends, from an order is placed until it is confirmed can be seen in Figure 4.7. Based on those findings, it can be concluded that the administration time of orders has impacted the lead time during 2019. The administration time has been at least one week, except for the last order, which was confirmed directly. According to Alloy, this time consists of document reviews and updating the production plan according to changes in BIOP's drawings and supporting documents. If this was communicated before placing the order, Alloy argues that the orders can be confirmed directly.

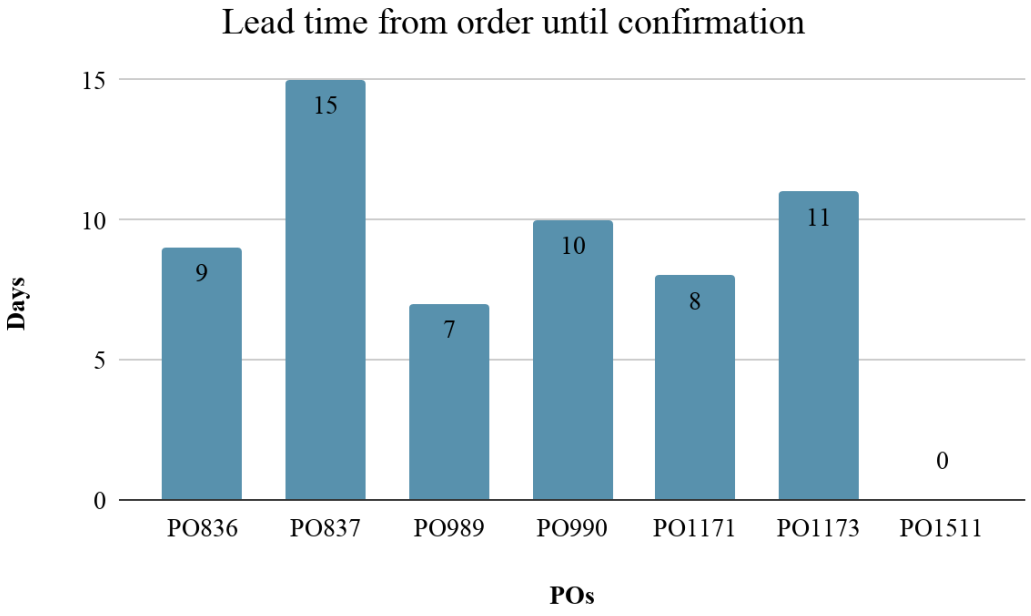

Figure 4.7: *The number of days it takes for orders to be confirmed by Alloy.*

A total of six articles included in Product X were selected for further analysis. Those will be referred to as articles A, B, C, D, E, and F. The choice of articles was based on several factors. The authors of this report identified both articles with a history of challenges and articles with less historical problems. Furthermore, articles that covered different production operations were chosen so that the set of articles would represent as much of the production steps as possible.

Figure 4.8 below is the result of a VSM performed at Alloy with the intention of following article A through Alloy's production steps. It was not possible to follow the article in real-time, and the VSM was therefore carried out through Alloy's ERP system together with the CEO at Alloy. The result is more of a process map than a VSM but provided valuable information for the project. Article A consists of several sub-articles, which are stated on the left side of the figure, and they together after individual processing time results in article A. The total throughput time is estimated to 35 working days, whereas 17 days is located at Alloy's suppliers, seven days at Clean Surface, and ten days at Coat.

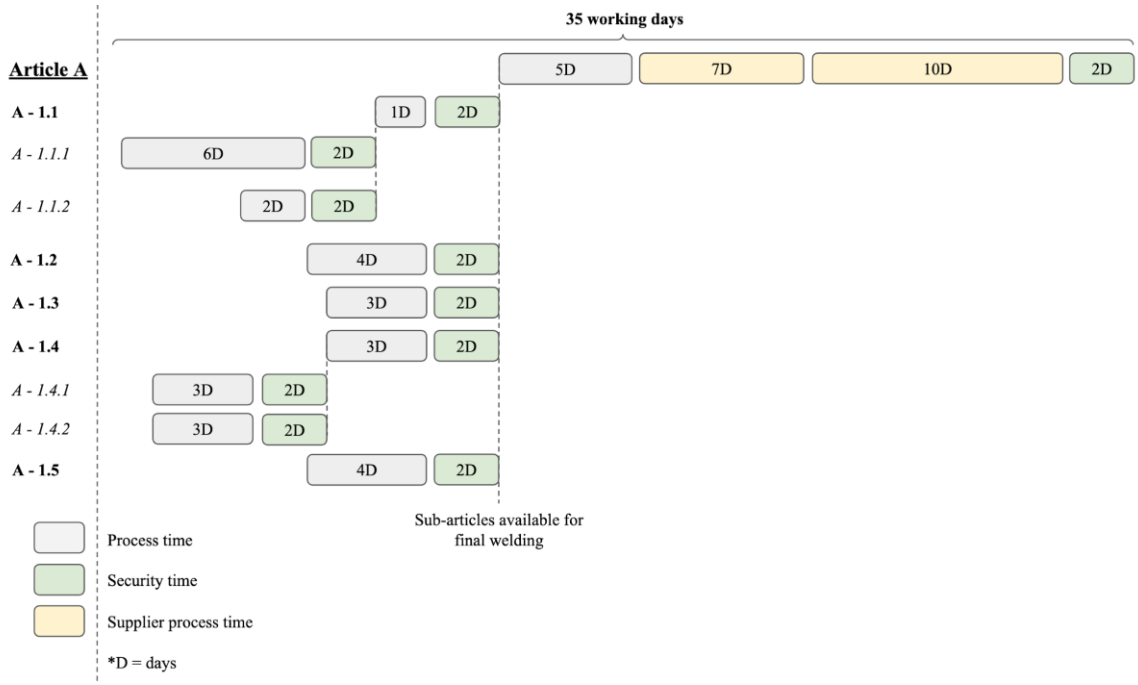

Figure 4.8: *Illustration of article A's process flow and throughput time.*

From the VSM, an analysis of value-added time was conducted. The data used is not statistics from the production, but instead the planned time for the processes. Sub-article A-1.1.1 of article A can be used as an example and is the first sub-article to be produced for article A, as seen in Figure 4.8. The planned production time is six working days and two days of security time. Security time exists in the production schedule to facilitate planning and allow for disruptions and disturbances. Producing sub-article A-1.1.1 consists of nine process steps, including internal transportation between facilities. The total processing time is summed up to 325 minutes, which corresponds to just over 11% of six working days. If the security time is included in the calculation, the processing time will represent 8% of the scheduled time. This indicates that a low amount of

time is value adding time. The remaining time consists mostly of waiting time. However, it has not been possible to map the time between processes further.

At the time of the data collection, article A was the article expected to have the longest throughput time. However, before this project started, other articles were driving the lead time when these articles were outsourced by Alloy to a milling company. Alloy has now invested in an internal milling machine to reduce the throughput time for these articles. The effect of this has not been possible to measure but is estimated to reduce the throughput time to under 35 working days, making article A the article with the longest throughput time.

4.4 DELIVERY PRECISION

BIOP's primary focus as a company is growth. Deliveries in time are critical since deviating deliveries affect resources at the company, causing re-scheduling with allocated time and additional administration time. Therefore, high delivery precision and communication about deviating deliveries are essential to reach minimal additional time spent on non-value adding activities in the supply chain. Delivery precision is often referred to as delivery performance in the literature, which entails deliveries on time and in the confirmed quantities. Accordingly, the ability to accomplish the confirmed lead time.

The delivery precision for Alloy's deliveries was calculated by evaluating every delivery in terms of quantity and whether the orders were delivered on the confirmed delivery date. The accepted delivery window was set to accept deliveries two days earlier than expected and up to one day after the confirmed date. All weekends and holidays in Sweden were excluded from the calculated delivery precision. The quantity was evaluated by comparing the actual delivery quantity with the agreed quantity. If an order was not fully delivered in terms of quantity, for example, 9 out of 10 articles being delivered in time, the delivery precision in terms of quantity was calculated to 90%. Final delivery precision for the six analyzed articles can be seen in Figure 4.9, with the delivery precision presented as the percentage of confirmed products delivered within the accepted delivery window. The data chosen were targeting all Product X orders during 2019, with some orders overlapping to both 2018 and 2020.

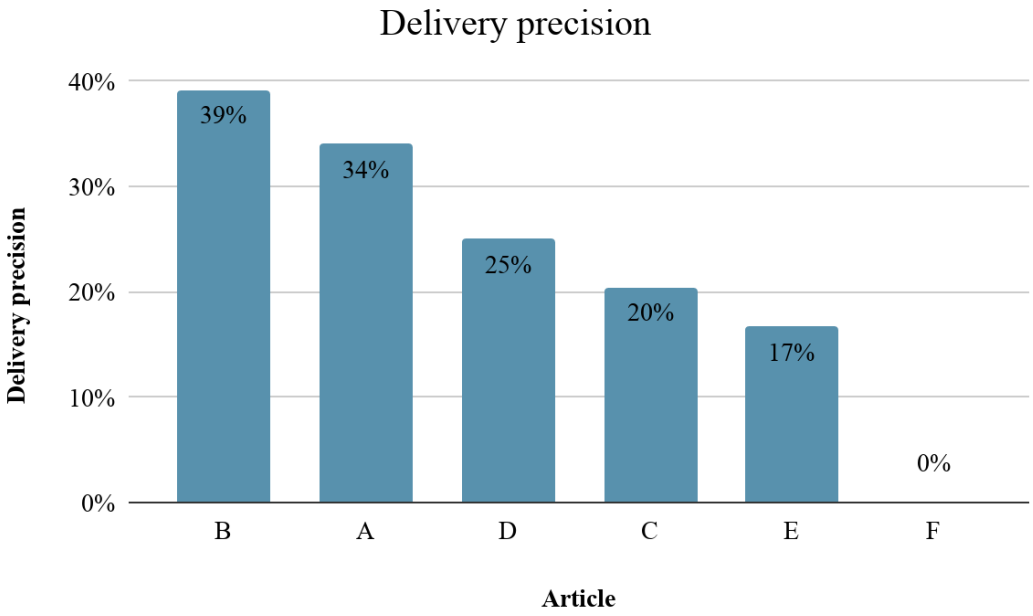

Figure 4.9: *Delivery precision for the six articles analyzed.*

The current delivery precision concerning Alloy's deliveries of Product X varies greatly, depending on which article is taken into consideration. Interviews held with BIOP's employees reveal quality issues regarding several products that have affected and decreased delivery precision. Article F stands out with 0% in delivery precision, and this can partially be explained by the low number of deliveries in the data. Only three deliveries were made of this article during 2019. However, none of them were delivered on time. Furthermore, Figure 4.9 is meant to illustrate that the delivery precision for the examined articles, in general, is low.

Figure 4.10 visualizes the delivery precision for the POs in 2019 for article A. The figure indicates no improvement, but rather a negative trend in 2019. The delivery precision during 2019 for the other five articles are outlined in Appendix A.1. Based on the qualitative data, article A is often delayed due to its complexity and recurring quality issues. However, the quantitative data in Figure 4.9 shows that this article has the second-highest delivery precision among the examined articles. This highlights the difference between the perceived state and the actual state.

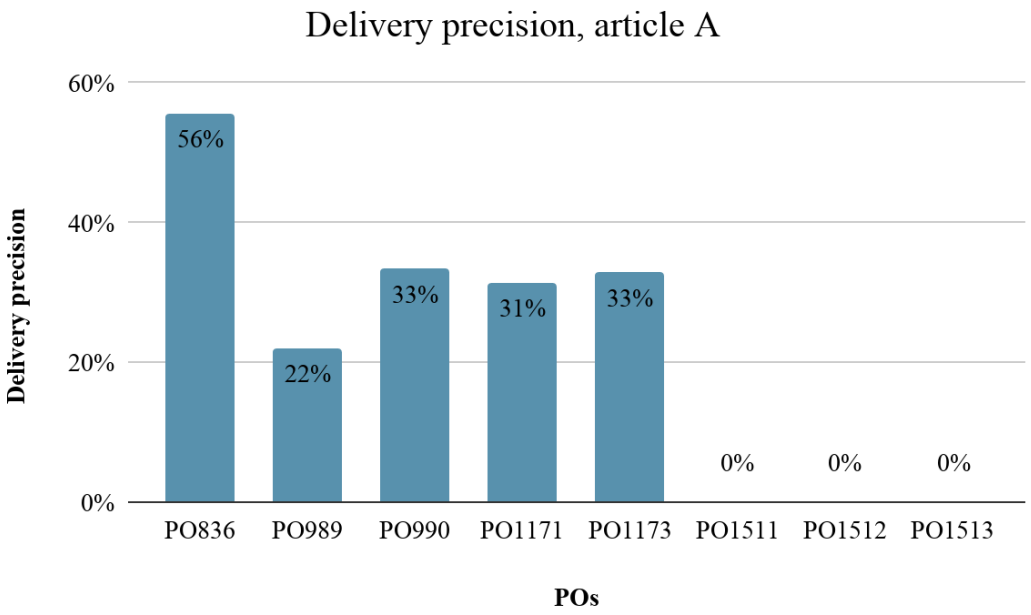

Figure 4.10: *Delivery precision for article A during 2019 in historical order.*

Alloy does not always send orders in the confirmed quantities to BIOP; deliveries with both less and more articles than the confirmed quantity are occurring. Data from the six articles analyzed showed that orders deviated from -14% to +20.0% of the original order quantity. The reasons for delivering a higher quantity was according to BIOP, probably to compensate for earlier delivered orders that had not been fully delivered because of, for instance, quality issues. Alloy explains that deliveries with lower quantities often occur because of quality issues or late deliveries from its suppliers.

Figure 4.11 shows the number of days between the confirmed first delivery date and the actual first delivery date for all six articles, and in Figure 4.12, a more detailed view is shown for article A. In this case, it can be seen that orders, in general, have been delivered later than expected and that the confirmed lead time is not the same as the actual lead time. Based on this information, it is possible to state that orders, in general, are late from the beginning and that for article A, there is no trend visible for improvement. Charts for the rest of the articles can be viewed in Appendix A.2.

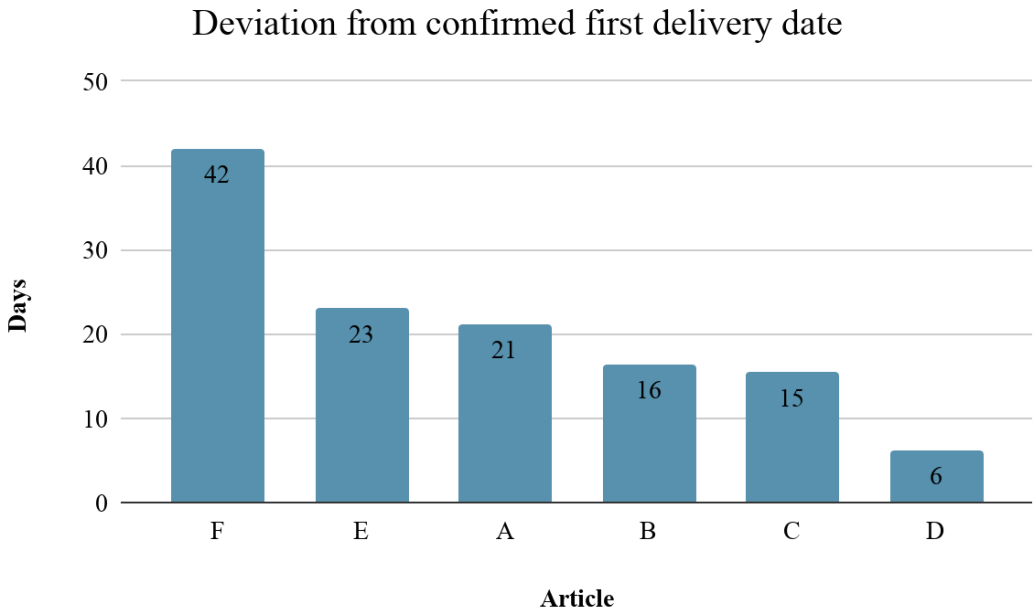

Figure 4.11: *Difference in days from the confirmed first delivery for the six articles.*

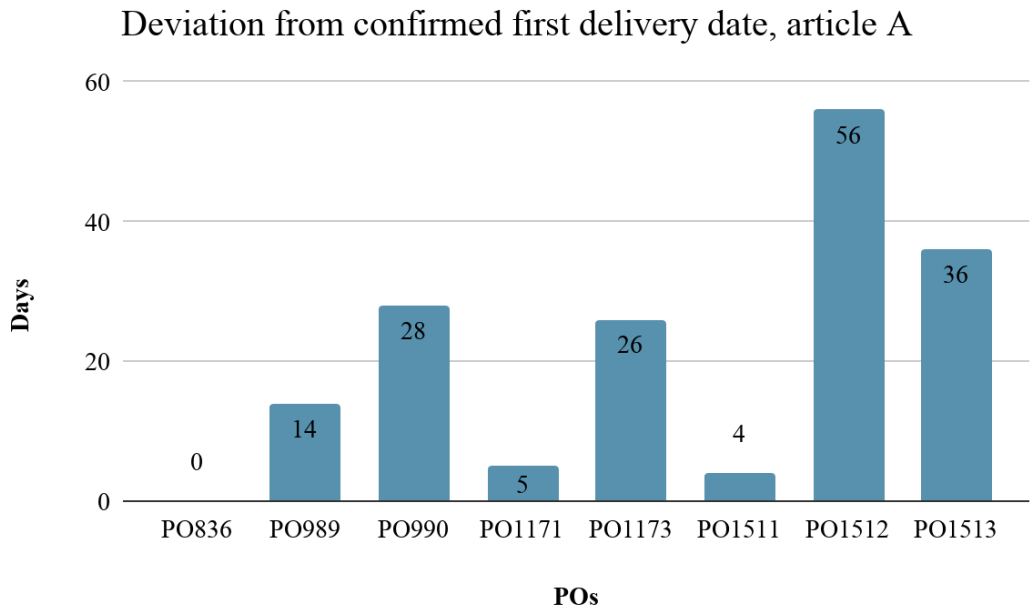

Figure 4.12: *Difference in days from the confirmed first delivery for article A.*

Another analysis that was executed was the difference in days from the date an order was confirmed to be fully delivered compared to when it was fully delivered. The confirmed last delivery date was therefore subtracted from the actual last delivery date. Figure 4.13 presents the deviation for the six articles studied based on several deliveries during 2019, and also here, a deviation is present. The result indicates that the articles analyzed depart on average between 16 to 68 days from the confirmed delivery dates. It is worth to notice that article E has the highest deviation; however, this can derive from several causes, such as depending on articles being wrongly reported in BIOP's ERP system, or that the communication about canceled articles has

been insufficient. The case study did not investigate how fast orders were registered when arriving at BIOP's facility. Figure 4.14 displays the deviation for article A, visualizing the distribution of the deviation for the POs during 2019. The numbers of days show the deviation in days, including all weekdays and holidays. From these two charts, it can be noted that all studied articles regularly during 2019 were fully delivered later than the confirmed date. Individual charts for the rest of the articles can be seen in Appendix A.3.

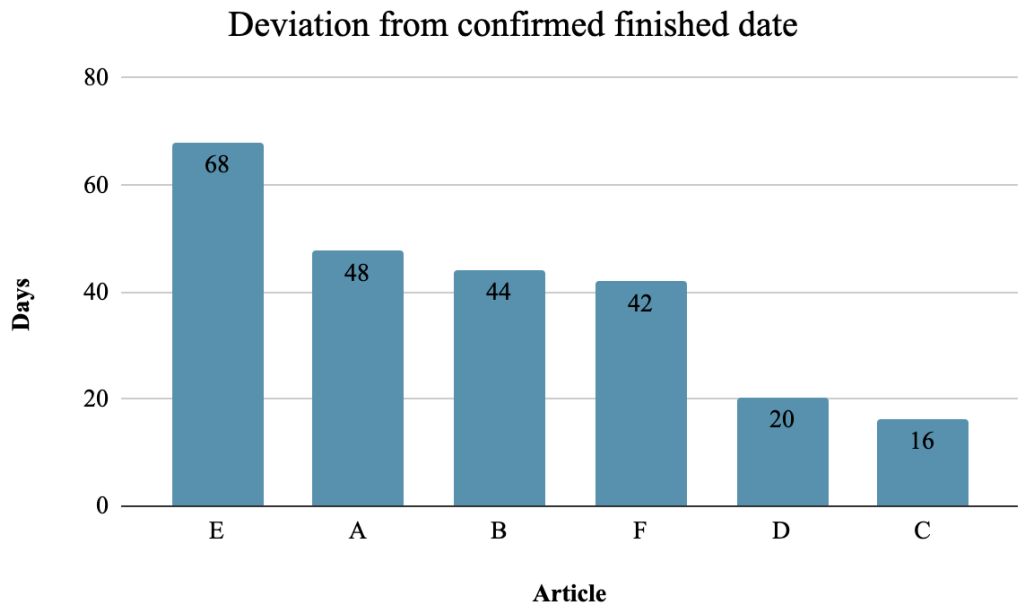

Figure 4.13: *Difference in days from the confirmed full delivery date for the six articles.*

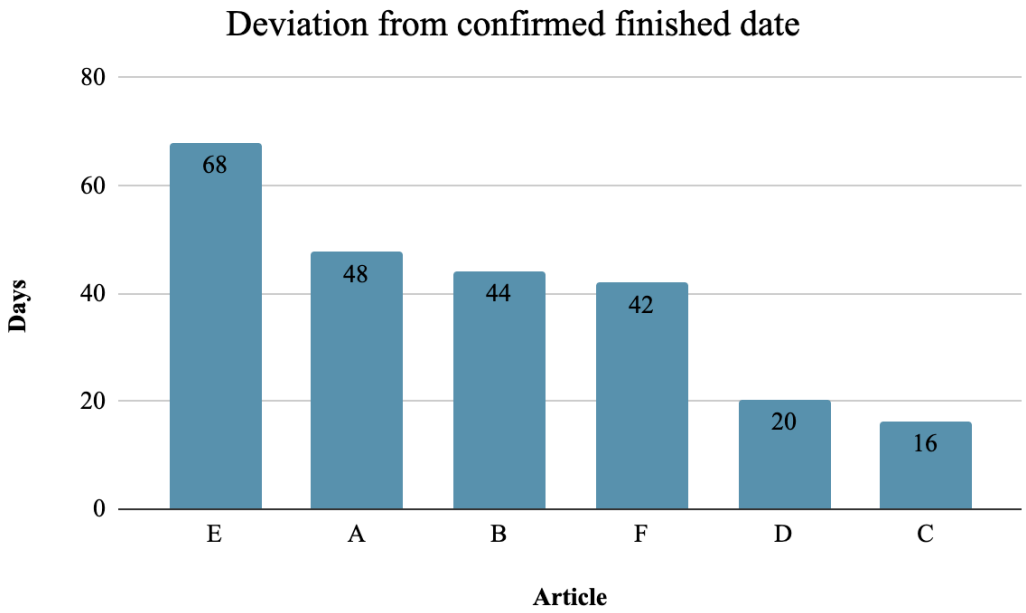

Figure 4.14: *Difference in days from the confirmed full delivery date for article A.*

Figure 4.15 presents the distribution of deviation compared to the confirmed finish date. Orders have, in general, been delivered later than expected, and the confirmed lead time does not

correspond to the actual lead time. For example, it can be seen that most deliveries are between 26 and 50 days late, and a total of 14 orders have been received in this span.

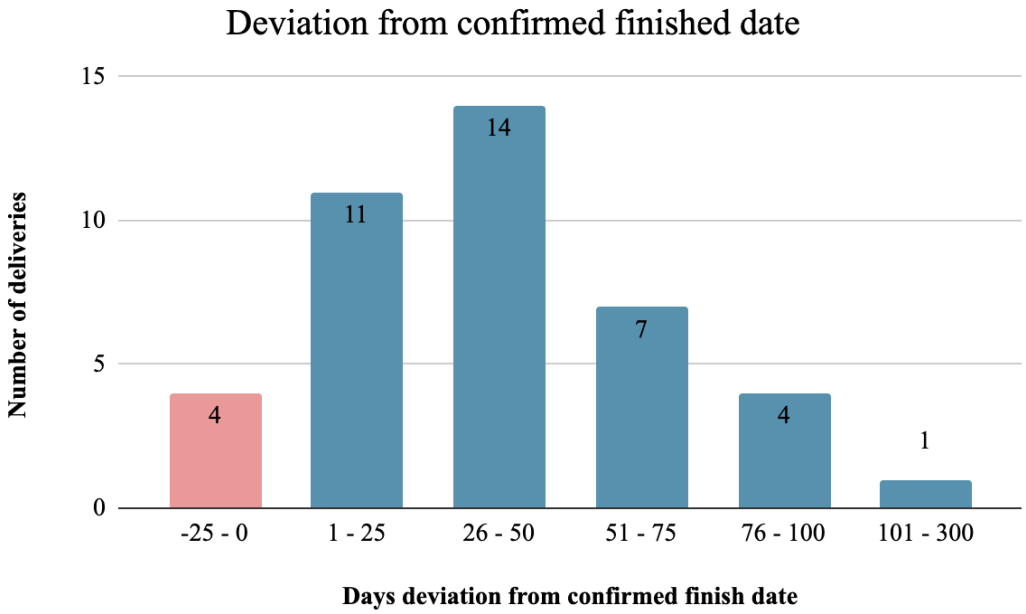

Figure 4.15: *Number of deliveries that have deviated from the confirmed finish date.*

4.5 LEAD TIME CHALLENGES

There are several areas at all supply chain partners that affect both the lead time and the delivery precision. In this section, challenges affecting the delivery precision and the lead time will be presented. The challenges depicted concern Quality, Pre-booking, JIT, and Forecasts.

4.5.1 QUALITY

The supplier and sub-suppliers in the given supply chain believe that the specification from BIOP regarding the surfaces and quality of articles leaves much room for their interpretations. The decided quality standards consist of verbal agreements, resulting in discussions about what is an accepted reclamation and not. Moreover, the suppliers experience higher requirements than stated in the drawings, and that drawings historically have been lacking detailed requirements. The suppliers would preferably see that BIOP lowered the requirement level on surfaces that are not visible to the customer since there are high requirements, even on these surfaces.

To further investigate the problems with quality, interviews were held at BIOP, Alloy, and Coat. It was found that the three supply chain partners all performed the quality inspections differently, even though the same quality standard was used. BIOP's Quality Assurance Manager explains that the standard leaves much room for interpretations since the articles are only controlled visually. The Quality Assurance Manager also states that BIOP's products are used close-up, and therefore need to be inspected with this into consideration. BIOP does quality checks usually within a week from arrival by inspecting the articles from a predefined distance and in specific light conditions. The quality assurance team studies the articles at a closer distance, and if an imperfection is

noticed, the quality operator steps back to the predefined distance to see if it can be seen at this distance as well. After that, the spot is marked out, and the Quality Assurance Manager performs a second quality check to confirm the operator's assessment. However, this is not corresponding with the decided standard since the spot should not be marked out for the second assessment since it then is easier to see the defect than if not marked. BIOP argues that it is difficult to find suitable replacement standards due to unestablished price levels. This means that a customized standard creates an opportunity for BIOP's suppliers to increase the price since the requirements are more specialized and do not represent industry standards.

4.5.1.1 RECLAMATIONS

Reclamations are highly related to quality challenges since it takes extra time and creates rework for all parties in the supply chain. The extra time is related to logistics and administration of reclaims, communication, and discussions about the responsibility for the quality problem, new production, and eventually redesign. When BIOP detects a defect on any article of Product X at its quality inspection, a complaint case is started and sent to Alloy. Depending on the cause of the complaint, different actions are considered. If Alloy do not agree with the complaint a discussion is started about the responsibility and origin of the deviation. Granted that Alloy accepts the reclaim, Alloy reworks the article or produces a new one. Alloy also sends reclamations to Coat if it believes the problem is connected to the coating. Additionally, internal reclamations exist at Alloy; however, those are not compiled and not easily accessible. The number of reclamations received by Alloy from BIOP during the last quarter has decreased according to BIOP's Quality Assurance Manager, which was confirmed by Alloy's quality inspector. Thus, since the internal reclamations at Alloy are not statistically complied, it is not possible to conclude the cost and time Alloy spend on internal quality issues. Neither does BIOP receive any information about them, which has been requested.

The final inspection of Product X at Alloy takes place two days before confirmed delivery to BIOP, just after all ingoing articles are finished. This leaves an insufficient amount of time for Alloy to solve possible problems before the confirmed delivery date. Alloy and Coat have agreed on a rework process of a maximum of ten working days. This means that when Alloy receives a product from Coat with quality issues, the article will be sent back, reworked, and, if possible, fixed in ten working days. The time it shall take for returning a reclamation between BIOP and Alloy is undecided, but have historically taken one month on average, according to the Quality Assurance Manager at BIOP.

4.5.1.2 COATING PROBLEMS

Both the CEO and Quality Controller at Alloy agree with Coat's management that the majority of the quality issues are exposed after coating. It is difficult to distinguish the responsible party regarding the quality issues; the issues could be associated with Alloy's production processes, but could also be a consequence of Coat's coating procedures. Coat has thus many demanding customers, including several players in the medicine- and defense industry. All these customers demand high quality. However, BIOP makes higher demands than these customers, close to

impossible demands, according to the management at Coat. The surface treatment at Clean Surface has been introduced as a consequence of the recurring quality problems connected to the coating.

The most common quality problems are according to BIOP, Alloy, and Coat, the finish of the coating, especially in welded areas where pores and bubbles create unsatisfactory finishes. The problems are especially problematic for parts that are visual for the end customer since the quality perception is essential for BIOP. For example, the Quality Controller at Alloy states that article A has a quality deviation rate of between 10-20%. These deviations are usually found in the welded areas during final inspection, when received back from Coat. According to Alloy and Coat, the defects are often approved by the assessment standard used for coating, but not approved by BIOP's quality checks. However, the involved parties have reached a mutual understanding of what is approved and not, but it does not correspond with the standard. In order to resolve the dispute with coating defects, Alloy employed a Quality Controller who dedicates almost all time to inspection of BIOP's products. Hence, a more in-depth understanding of the problem is reached and more frequent communication with BIOP regarding the quality expectations.

4.5.2 PRE-BOOKING

Coat requests pre-bookings from its customers to offer fast lead times and excellent service. Pre-bookings allow Coat to plan its occupancy and availability and, therefore, wish that Alloy would make pre-bookings as early as possible, but at least four weeks before delivery. This research discovered that Alloy never pre-books in the way that Coat has requested. Alloy notifies Coat the same day it ships the products, which is not optimal for Coat. If Alloy would start pre-book, the lead time is confirmed to be reduced by half, from ten working days to five working days. This would probably impact the delivery precision from Coat to Alloy according to the interview with Coat. Coat states that it has 99% delivery precision on pre-booked orders, compared to 95% delivery precision on all orders, including orders not pre-booked. According to the CEO at Coat, the decrease in delivery precision is mainly connected to Alloys' orders. However, Alloy has no routine for pre-booking when it confirms an incoming order. This would, according to multiple sources, require more planning in detail for the company. The many processes involved in Product X and the complexity of the articles make deviations in the time-plan not uncommon. Alloy also describes sickness and other staff disturbances as an obstacle with a more compact time-plan.

The delivery precision for article A during 2019 was 75%, approving deliveries up to one day after the confirmed delivery date and two days before. When analyzing the data from 2020 with the same article, 92% of the deliveries arrived on time. The improved delivery precision was explained by improved control over planning, realistic delivery dates set to Coat, and fewer quality problems.

Alloy ships two articles to Anode for blasting and anodizing. These articles receive a reinforced oxide layer over the aluminium layer. Alloy provides its own transportation, and with the current batch size, the lead time for blasting and anodizing is between ten to twelve working days. Pre-booking is not used, and the effect on the lead time has not been further investigated. However, the person responsible for logistics at Alloy believes that lead time reduction is also possible in this interface if starting pre-booking deliveries.

4.5.3 JIT

Alloy has adopted JIT in its planning and production. This implies planning backward and executing a preparation for each item that generates a lead time depending on the capacity defined in each production group. If a customer order is received and the delivery date is, for example, in 50 days, the order will not be released automatically. Instead, Alloy estimates the required production time and then starts the production as close to the delivery date as possible. If the delivery is scheduled in 50 days, and the estimated production time is 25 days, the production will start 27 days before the confirmed delivery. This leaves two days of security time after the finished production. JIT has many benefits but also makes the production vulnerable to disturbances. As described previously, many of the quality problems are discovered late in the processes and if the order is planned to be finished as late as possible, there is no time to correct the problems. Alloy's CEO states that JIT has reduced the number of active production orders by 50%, which leads to less WIP, and less inventory.

Another challenge connected with the JIT planning is that Product X's articles seldom arrive all together and BIOP needs all articles to assemble one set of the product. Therefore, these problems force BIOP to constantly have a higher safety stock to secure its own delivery precision. The production process is different for each article in Product X, and together with the JIT planning, not much time is left for delays in the production.

4.5.4 FORECASTING

It is of utmost importance to have a forecast for the future demand for the suppliers in the supply chain to prepare production and businesses. This is a problem acknowledged by all suppliers involved in this project, and BIOP has seldom delivered a detailed forecast according to them. Due to internal communication issues as well as internal development obstacles at BIOP, the forecast given to the suppliers has sometimes been inaccurate. As a consequence of this, the suppliers, especially Alloy, have not been comfortable maintaining a safety stock for BIOP, since the orders are irregular and the future orders uncertain. During an interview at Alloy, it was revealed that more reliable forecasts would probably reduce some of the delivery problems. Alloy indicates that it could then produce stock to cover up for unexpected disruptions. Without assurance of future orders, Alloy is not comfortable with storing products not ordered by BIOP.

One reason for unreliable and changed forecasts is the release of new product versions. For example, a new version of Product X was expected in Q3 2019. However, due to delays in the development of the new version, it was still not in production in Q1 2020. This made Alloy remove its safety stock in the second half of 2019, to reduce the risk of storing products which would not be ordered by BIOP. Orders for Product X had been communicated to be placed once every quarter but were also postponed due to the new version release. This created a scenario where Alloy increased its capacity at the beginning of 2019 to handle the production and decrease the lead times. When BIOP then stopped ordering to clear out its stock of the old version of Product X, Alloy was forced to give notice to employees due to the decrease in production.

A situation, as described above, can not always be foreseen; however, the communication could, according to Alloy, be more intense during the period to help Alloy prepare and understand future demand. Since Alloy has a significant amount of its revenue from BIOP, Alloy is consequently in high demand for its orders. According to Alloy's CEO, forecasting and insight into the underlying demand are of high importance. Another communication from BIOP that would facilitate Alloy's handling of orders would be if revisions were continuously received. Thereby, Alloy could have updated revisions when receiving a new order from BIOP.

4.6 RELATIONSHIP CHALLENGES

Alloy is the main supplier taken into consideration in this study, and its supplier Coat, Anode, and Clean Surface. The suppliers experience several challenges related to the relationships within the supply chain.

One challenge is the high-quality standard that BIOP is requesting. The demand for superior quality from BIOP leads to difficulties in producing the articles and consequently, higher costs for the suppliers. An example of this is when surface treatment was added before the coating to minimize rework and reclamations. This process increases the cost of the products, and Alloy experiences problems with adjusting the price for such activities. Alloy prefers long partnerships with its customers. However, Alloy does not get any guarantees to be the future supplier for Product X because no formal contracts are aligned between Alloy and BIOP to produce a certain number of products each year. BIOP is continuously evaluating its suppliers and seeking optimizing cost and quality; therefore, new suppliers are examined. Alloy is aware that BIOP is evaluating other suppliers to execute the manufacturing, causing uncertainty about the future and how much to invest in this relationship. The uncertainty results in Alloy being vigilant against BIOP and hence, limits information sharing to keep its supply benefits. Those include specific information about how to produce Product X and reach high-quality requirements.

The limited trust between BIOP and Alloy was noticeable during the research and limited the data collection and information sharing. As BIOP believed that no barriers were present, the authors experienced it first hand. Detailed production data was restricted, and Alloy explained that due to the uncertainty about the future, sharing information that could be useful for competitors is not encouraged. Alloy possesses production techniques that make it difficult for BIOP to change suppliers, even though it is not impossible. The Head of Hardware at BIOP expresses concerns with how time-consuming it would be and that Product X is partly customized for Alloy's production. BIOP has, as described, evaluated its alternatives for supplying the metal construction for Product X. However, it has hitherto concluded that no other supplier can reach the same high quality as Alloy, which is further claimed by the CEO at Coat. Coat cooperates with several similar production firms, and Alloy's performance is industry-leading, according to Coat. This increases BIOP's dependence on Alloy, and strengthens its position against BIOP as an exclusive supplier.

Consequences of BIOP not having reliable and contracted forecasts are, according to Alloy, increased internal costs and insecurities in how to invest its resources. For example, when BIOP decreased quantities for Product X during a specific period, this caused the unit price at Alloy to

increase since it has calculated economic order quantities for higher volumes. This example highlights the importance of Alloy to achieve the optimal economic price point for the company, and accordingly optimize costs, but also the importance of the communication about forecasts to be reliable and updated in time.

One of the most evident problems for BIOP is that Alloy does not keep the accepted delivery dates. However, BIOP also expresses concerns about the communication of late deliveries. BIOP's Purchaser states that seldom any prior information about the future deliveries are communicated. The narrow communication limits BIOP ability for internal planning and staffing of its assembly production. Unreliable deliveries force BIOP to have a stock, which is not prefered. It is also problematic when BIOP introduces a brand new version of a product, and deliveries from old versions are still not completed from Alloy, meaning articles are delayed and no longer requested by BIOP.

Furthermore, BIOP's Purchaser expresses a lack of information about the causes of the delays, and also, how late the articles will be, or if they will be canceled. These concerns have been confirmed by the CEO at Alloy, elaborating that no routines for delivery communication have been established in the company. A canceled delivery occurs according to Alloy when articles are complained about and can not be fixed, and the production becomes too expensive to start producing individual articles.

Another challenge for the supply network is the trade-off between cost and quality. Both Alloy and Coat experience BIOP's quality demands as higher than the industry standard and are having a hard time achieving these high demands and, at the same time, keep the low prices that BIOP is also requesting. Alloy and Coat are both positive to keep developing the quality level, but if investments are made, the price also needs to follow. Furthermore, Alloy experiences that BIOP often opposes price increases and tries to retain the same price levels, even though the circumstances have changed.

4.7 PROTOTYPE PROCESS FLOW

BIOP has a product development department that is focusing on updates, modifications, and improvement of current articles and products, but also the development of new products. In compliance with the focus on growth in the company, the department has ambitious visions and high expectations to perform well. When performing NPD or upgrading already existing products, BIOP is using prototypes to produce and test the function and design before actual production. Hence, BIOP is in addition to the regular deliveries, also ordering prototypes from Alloy. The Head of Hardware at BIOP estimates that at least one prototype per month is produced. The product development team often administers those deliveries at BIOP, which, according to the Purchaser at BIOP, raises problems in planning and prioritization.

The process for prototypes can be as following; a team member in the development department raises a suggestion on an improvement on Product X, and the Head of Hardware investigates the costs and possibilities for further development. The Head of Hardware takes a decision as soon as

possible and decides whether to continue with the development. If the improvement is going to be initiated, the next step is to contact the Vice President at Alloy to investigate the current capacity and discuss the new design. Supporting documents are sent to Alloy to check if any feedback can be provided. Alloy has to agree on production changes, even if not a prototype is necessary to produce. If a comprehensive update is going to be initiated, a start-up meeting between Alloy and BIOP also takes place. The product development team at BIOP sends a 3D model file and 2D drawing when the improvement is ready for production. An illustration of the workflow for prototypes can be seen in Figure 4.16, where several interactions between BIOP and Alloy are present as described.

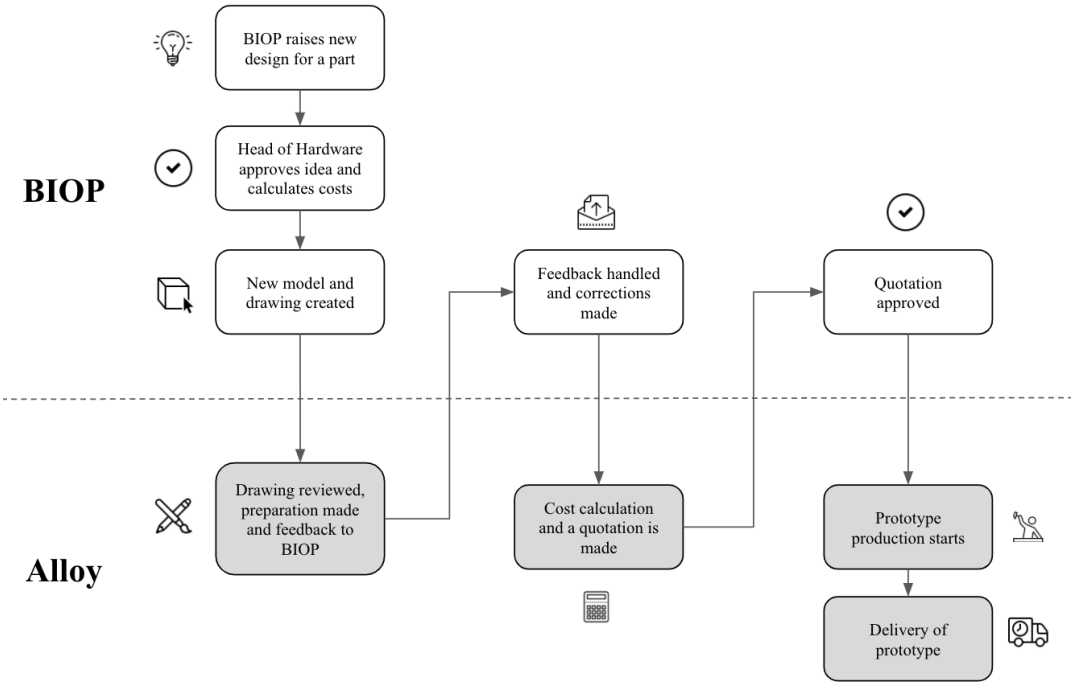

Figure 4.16: *Prototype workflow.*

BIOP believes that introducing an improvement that would make an article easier to produce and cheaper, is also of interest for Alloy to prioritize. BIOP would appreciate faster handling of administration to new prototypes and improvements since it experiences that it takes a long time before Alloy starts producing the prototypes. BIOP believes that Alloy can utilize the capacity better than currently and promise shorter lead time. Nevertheless, when Alloy receives a new design or construction from BIOP, it is generally hard for Alloy to make more extensive adjustment proposals and feedback since BIOP already has spent a significant amount of time in the design phase. Therefore, BIOP might be unwilling to start over again, and it might be too late for valuable input. Alloy believes it would be of importance to start a discussion earlier, to get involved in the development, and receive continuous feedback throughout the development.

Moreover, early involvement in the development could ease a lot of the quality challenges. The Vice President at Alloy experienced it challenging to detect all possible problems when receiving the design in the later stages and everything at once. If updates from BIOP were received along the way, it would be easier for Alloy to detect what is possible and not possible to produce, which

would save both time and costs for BIOP and Alloy since it hopefully would reduce the unnecessary production problems. Furthermore, the Vice President at Alloy explains that the administrative processes for the prototypes can be burdensome due to the unorganized version management of the 3D-models. It can be challenging for Alloy to see what is changed since the last update, and therefore, has to go through all files again to identify what has changed and made new calculations for price and production data.

The lead time for prototypes varies depending on the complexity of the prototype and which processes it has to pass through at Alloy. Generally, it takes a long time since prototype production is not a straightforward process and typically requires iterations and adjustments. Alloy plans prototypes in the same way as regular manufacturing orders. The process starts with the registration of a customer order, which generates a manufacturing order proposal. The Production Planner releases and plans the manufacturing order after that to deliver the order on time.

4.8 PERFORMANCE OBJECTIVES

In order to distinguish the operational priorities for the products in the exchange between BIOP and Alloy, key personnel at both companies were asked to assess the importance of the five performance objectives presented in Section 2.4.1 - *Performance objectives.* The five objectives were set in relation to the expectations perceived by the participants. Participating personnel were asked to rank each objective on a scale from 1-5, where five is of utmost importance, and one is of low importance. Alloy's participant was asked about the perception of BIOP's priorities, and how the priorities set by BIOP was experienced for Alloy's deliveries. In Table 4.1 below, the answers are presented.

Table 4.1: *The Five Performance Priorities applied to Alloy's deliveries.*

Objective	**Head of Hardware - BIOP**	**Purchaser - BIOP**	**CEO - Alloy**
Cost	4	4	4
Quality	5	5	5
Speed	3	5	3
Flexibility	2	3	3
Dependability	4	5	3

5. ANALYSIS

In this chapter of the report, the findings from Chapter 4 - *Empirical findings* will be analyzed using the theory from Chapter 2 - *Theoretical framework.*

5.1 APPLYING A PURCHASING MODEL

As a buying company, it becomes vital to decide which kind of relationship that is suitable for each supplying possibility. Figure 5.1 places Alloy in the Kraljic matrix judged on profit impact and supply risk of the purchased items (Caniels & Gelderman, 2005). Product X can be seen as a strategic item with high supply risk since BIOP has no alternative supplier for this product. The profit impact is also considerably high due to the expense of the articles supplied by Alloy compared to the total cost of Product X. Therefore, establishing a partnership is a priority for BIOP as a buying company.

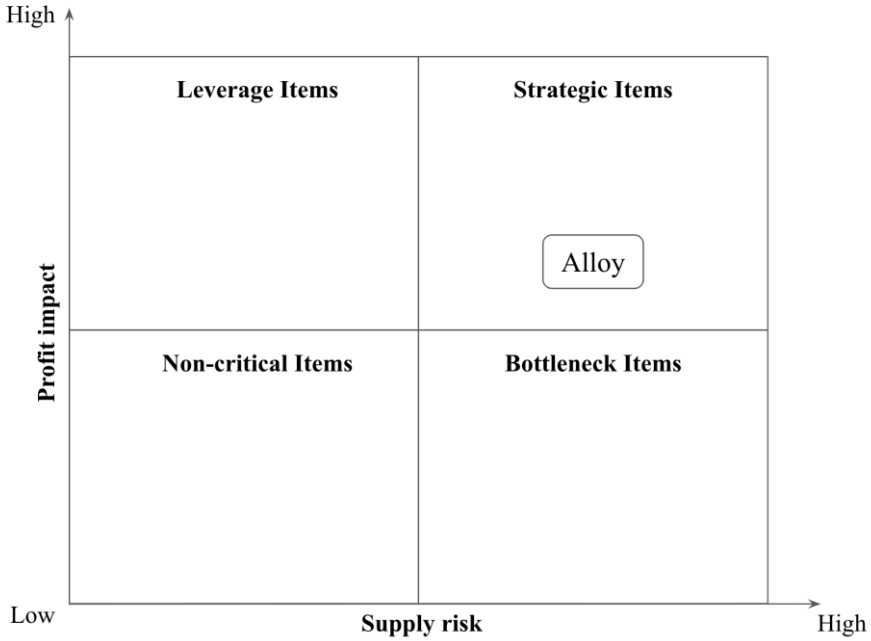

Figure 5.1: *Alloy in relation to the Kraljic matrix.*

5.2 BIOP'S FIVE PERFORMANCE OBJECTIVES

During the project, it became evident for the authors that the operational priorities were undecided at BIOP or miscommunicated to the supply chain partner Alloy. Therefore, this section will cover an analysis of how the priorities are perceived by both BIOP and Alloy. As presented in Section 2.4.1 - *The five performance objectives,* an organization's performance can be divided into five objectives, representing areas that the company needs to decide on how to prioritize. Depending on the market situation and the company's business idea, organizations can prioritize this differently (Slack et al., 2007).

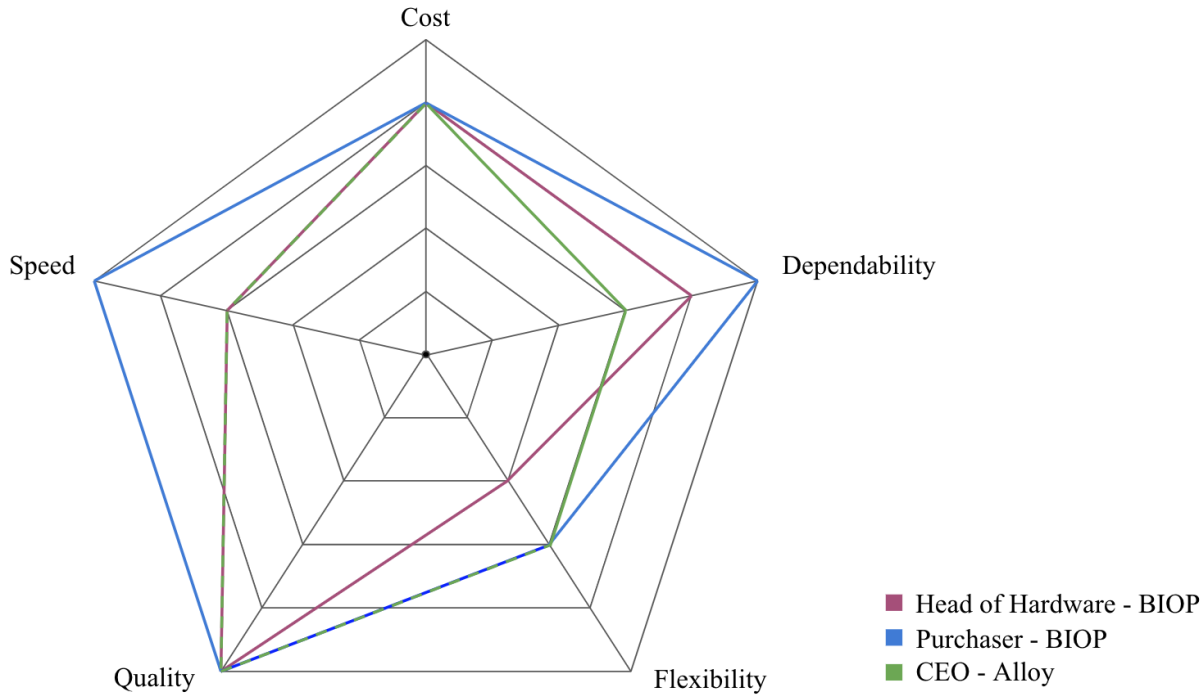

Figure 5.2: *Illustrating the performance priorities, as stated by BIOP and Alloy.*

The priorities presented in Figure 5.2 are representing the priorities in the relationship between BIOP and Alloy precisely and not the overall organization priorities. As illustrated in Figure 5.2, the performance priorities between Alloy and BIOP are neither synced nor between the departments at BIOP. However, quality is by all parties perceived as the highest priority, and the objectives are synced correctly. The situation is similar for the cost objective, the view is shared, but of lower priority than quality. For the rest of the objectives, the priorities are not corresponding to all parties.

Firstly, the situation with the trade-offs can be described. As both Tersine and Hummingbird (1995), and Slack et al. (2007) state, an organization can not prioritize all objectives simultaneously but instead needs to carefully decide where the organization has the most advantage of focusing its efforts. If it were possible, all companies would prioritize all objectives. However, it is often not possible to achieve the highest quality on the market and, at the same time, similar low costs. In this case study, all parties agreed that the quality should be of the highest priority and that the cost should be kept low. The trade-off becomes vital since the conflicts from this where many. As presented, Alloy experienced difficulties in achieving the high quality BIOP requires and, at the same time, keeping the costs down. In order to meet the quality demands, Alloy has, for example, added new processes to the manufacturing and increased the frequency of quality checks throughout the production process. To maintain profitability, Alloy has increased the price to BIOP successively. Bergman and Klefsjö (2010) imply that improved quality often results in improved profitability, which leads to remarkable leverage effects. However, the quality work and inspections implemented by Alloy have not solved all the root problems, mostly preventing them from reaching the end-customer. The problems are monitored, and the inadequate articles are reworked. Nonetheless, by monitoring the problems, a deeper understanding of the quality deviations can be reached, and they can be permanently dissolved in the future. In the current

situation, quality and cost are a trade-off, but by continuing the focus on quality, the cost will, in the future, be reduced by the efforts. Eventually, Alloy could reach shorter lead times, less rework, and reduce costs.

Dependability of deliveries is perceived as a rank of three for Alloy and by BIOP's Purchaser as a five in priority. This result creates a scenario where the expectations are significantly deviating, and BIOP's Purchaser expects dependable deliveries as necessary, and Alloy's perception is that this is not equally important.

5.3 TRANSACTION COST ECONOMICS EFFECT ON THE SUPPLIER RELATION

The authors found the connection between current buyer-supplier difficulties and the theory of TCE interesting. To a great extent, a lot of the disputes found in the relationship can be connected to the theory presented by Coase and Williamson. The theory can be analyzed based on the three areas that Alchian and Allen (1972) introduced; search costs, bargaining costs, and policing costs.

5.3.1 SEARCH COSTS IN TCE

As a buyer-supplier relationship is about to be established, a transaction is desired, and the research needed to identify the correct supplier can be both tedious and challenging. In this case study, BIOP and Alloy have already established a relationship, and the search cost is instead related to finding alternative suppliers to Alloy. However, as presented in the theoretical framework, the search for a transactional partner can be demanding, especially since the product, in this case, is specific and unique. This fact, together with the informational power possessed by Alloy, prevents BIOP from establishing alternative supplier relations and strengthens Alloy's position in regard to BIOP.

5.3.2 BARGAINING COSTS

Establishing a contract is the second category in the prepayment of a transaction. When applied to this case, the standard for assessing coating quality is firstly analyzed, and after that, the contract between BIOP and Alloy regarding future orders. The standard used for quality checks has, as presented in the Empirical Findings, shown to be inaccurate to BIOP's expectations. However, the establishment of a complete standard is connected to high costs. Identifying a sufficient standard has been difficult to accomplish by BIOP, and its second option is to construct a standard fulfilling its targets. Nonetheless, the costs of bargaining and negotiating a new standard with the supply chain partners will also be complicated and, therefore, expensive. BIOP is also concerned about the price level a self-produced standard could inflict as there are no guidelines to use when constructing a new standard. Furthermore, Alloy and Coat both agree on the current standard as an established standard, and requirements higher than this standard are complicated to reach, if even possible. This situation creates a high cost for establishing an agreement since all parties must agree on the standard used, and also agree on the price of the new standard.

As stated before, there is currently no agreement or contract established between BIOP and Alloy regarding their partnership or recurring orders. The contract is more of a mutual agreement with an order confirmation as the primary document representing every transaction. The main reason for this is the uncertainty in quantities since BIOP does not want to be bound to a specific ordering quantity, as it strives to be flexible depending on its underlying demand. However, a desire for a policy contract is present from both parties but has been postponed due to complication of establishing one. A more elevated contract could ease the next area to be discussed, the policing costs.

5.3.3 POLICING COSTS

As the contracts are unsatisfactory, the compliance of the transactions suffers from this. Deliveries after due date have no penalizing consequences, and this could be because of BIOP's insufficient efforts in establishing it in the contracts. Even though both parties accept the delivery date, the deviations from this are frequent, and there are no actions to prevent it. Therefore, it is complicated for BIOP to follow up on what it considers breaches of the agreement. This applies to the quality standard as well, when BIOP receives products that are not satisfactory to its means. BIOP returns the product, and by doing this, consequently, it has established a mutual agreement of what is accepted and what is not. However, this has been a high policing cost as it has required a considerable amount of time to discuss the returns, and decide who is responsible for the quality deviation and who should cover the cost of reworking the product.

5.3.4 WILLIAMSON'S DIMENSIONS FOR ASSESSING THE TRANSACTION COST

Williamson stated three dimensions for assessing the transaction cost; uncertainty, frequency, and relation specific investments. Those dimensions could be used as a base for determining if the transactions should be vertically integrated or not.

Uncertainty surrounding the transactions can be linked to the difficulty of determining the price of the products since there are no similar products to use as a reference in this case, and hence all price adjustments become a subject for negotiation. Due to the low transparency between Alloy and BIOP, there are challenges for both parties to understand why the other party suggests an adjustment. There is also uncertainty present regarding the future because none of the parties are certain about the future cooperation.

The transactions of Product X are currently meant to happen four times a year. One order is placed every quarter, and a few additional complementary orders are added to that. For BIOP, this can be considered a relatively high frequency, and every order creates a new negotiation of price and delivery time. A high frequency can reduce the transaction cost as the process becomes more and more standardized, and only adjustments are needed for every new transaction.

Relation specific investments are, in this case, considerably high. Both Alloy and BIOP have placed a lot of time and resources into developing the products transferred in this exchange. BIOP

has put much effort into developing the design and construction of parts, and Alloy has invested a lot in operations to achieve the results that BIOP expects.

5.4 THE SUPPLIER RELATIONSHIP BETWEEN BIOP AND ALLOY

From the interviews, it became clear that BIOP has as a strategic decision chosen to outsource some parts of its processes to Alloy, in other words, make a 'buy' decision, while performing the final assembly in-house (Rolstadås et al., 2012). This decision affects other strategic decisions within the company, according to Rolstadås et al. (2012), and is therefore of importance for BIOP.

There are several advantages of outsourcing, which is argued by Kannan & Tan (2006). For example, BIOP can utilize its resources in a better way since outsourcing frees up capacity and enables BIOP to focus on its core capabilities. Moreover, BIOP can take advantage of Alloy's expertise and previous knowledge in the specific manufacturing area. Furthermore, outsourcing enables BIOP to create values that the firm can not create without collaboration, which is stated by Nyaga et al. (2010). Although, there are also risks present when choosing to outsource externally. Krause et al. (2000) underline that the supplier's performance is critical to the long-term success of the buying firm since suppliers have a direct impact on many competitive dimensions. Krause et al. (2000) suggest that a buying firm, like BIOP, should perform intervention with its supplier to ensure that BIOP's future needs and expectations are possible to meet for Alloy. Another risk with outsourcing is regarding the transfer from tacit to explicit knowledge, as presented by Rolstadås et al. (2012) and Guo et al. (2010). The supplier relationship needs to use codification of knowledge to make the knowledge more explicit.

ESI is further a concept that is important when outsourcing, and involves the sharing of knowledge early in the process (Rouibah & Caskey, 2005). The use of external knowledge in NPD has been considered to result in positive effects and is, therefore, appropriate for BIOP (Rosell et al., 2017). Although, the openness involved raises concerns in the commercialization of innovations, which requires protection (Knudsen and Mortensen, 2011; Laursen and Salter, 2006). This could be a concern in the studied case since BIOP is a highly technology-intensive company, and if new technological ideas are shared with suppliers, there is a risk for competitors to become aware of new product ideas.

Sharing knowledge within a supplier network can often be beneficial for a firm, and BIOP can advantageously share resources such as knowledge assets with Alloy (Dyer & Hatch, 2006; Lind & Melander, 2019). Currently, this is not prioritized by BIOP based on various reasons. A buying firm's direct investments aiming to improve a supplier's performance can reduce a buying firm's transaction cost from a long-term perspective (Krause et al., 2000). However, BIOP seems to not always value its relationship with Alloy since it does not give Alloy any guarantees for further collaboration, and does not communicate forecasts enough. Alloy requests long-term guarantees and investments and concludes that it would, in that case, be more willing to streamline processes, make new investments, and overall invest more in the collaboration.

5.4.1 RELIANCE AND INFORMATION SHARING

Reliance is an essential factor in the relationship between a buyer and a supplier (Kannan & Tan, 2006). From the interviews, it was found that Alloy does not rely totally on BIOP and whether Alloy will sustain to be the leading supplier for Product X since BIOP also has collaboration with other suppliers, causing uncertainty in the relationship. Hallikas et al. (2004) state that reliance is a prerequisite for networking and creating partnerships, which is mentioned to be prioritized by Alloy. Networking can, for example, be of advantage during product development (Takeishi, 2001). BIOP and Alloy have joint meetings and development discussions during the prototype development, but Alloy is open for even more interactions and involvement earlier in the process. If the development involvement increases, it can result in reduced transaction costs, the ability to concentrate on core skills, access to critical technologies, and evolving risk-sharing among partners (Hallikas et al., 2004).

The open book theory is connected to reliance and information sharing in the supply chain. It is a balance between maintaining informational power and developing a deeper relationship (Caldwell et al., 2005). If Alloy would be confident in the relationship with BIOP, the information sharing could be increased, and BIOP's understanding of cost drivers could be eased by a total transparency in Alloy's production costs. Agndal and Nilsson (2008) indicate that sharing cost and data between a supplier and a buyer would facilitate a joint development according to the open book supply chain theory. Also, Cooper (2017) suggests that increased information sharing in the interfaces between companies will result in more substantial confidence in the relationship, which hopefully reduces uncertainty.

The information sharing could also benefit from a more transparent information exchange from BIOP regarding the forecast and underlying demands. A transparent information sharing could increase Alloy's understanding of the deficient forecast and help Alloy manage changes in the demand. This action is corresponding with Lamming et al. (2005) statement, who proposed transparency, and that both parties open their books instead of one-way open book negotiation where only one party is subject to transparency. The same authors further argue that transparency should be applied in a stable and long-term relationship, and in this case, indications of instability are present.

When one party possesses information that can influence another, it is called informational power (Raven, 1965). In this case study, the supplier has the possibility to use its expertise as informational power. Alloy has detailed production knowledge on how to produce parts for Product X that makes it difficult for BIOP to replace Alloy. Alloy might not intend to use the information possessed; however, due to the dependence of BIOP's orders, the information is kept within the organization to prevent BIOP from changing suppliers. This essentially means that Alloy is using its information advantage to retain the customer and is a common situation for a small supplier (Siemieniako & Mitręga 2018). Dubois and Pedersen (2002) acknowledge that many purchasing models aim to either exploit the informational power or prevent being exploited by it. BIOP has tried to manage the imbalance in their power relation by exploring other suppliers; however, this has been seen as a coercive power method by Alloy and instead made Alloy more

restricted with sharing information. Even though BIOP does not intend to be hostile, it is easily interpreted this way and is not recommended as a strategy for a long-time partnership (Lacoste & Johnsen, 2015).

Motivating suppliers by using incentives is vital, according to Krause et al. (2000), and using competition to motivate suppliers to develop. BIOP has engaged in supplier alternatives to evaluate its options and to motivate Alloy to continue developing its business. Incentives could also, as stated by Krause et al. (2000), motivate the supplier to improve and develop. In this case study, the competition has affected the supplier to become insecure in the relationship, and instead of developing the relationship, the collaboration becomes hindered by a more substantial commitment to the informational power possessed by Alloy. The same authors propose active involvement, which is also hindered since Alloy is restrictive with what information is shared with outside parties.

5.4.2 SUPPLIER-PARTNERING HIERARCHY

The supplier-partnering hierarchy described by Liker and Choi (2004) consists of six steps for a successful partnership. In the relationship between BIOP and Alloy, the first step is achieved through the long history of collaboration between the firms, which have guided them to an understanding of each other. The second step has been tested by BIOP to increase the rivalry. However, this has not had any positive impact on Alloy. BIOP is still single-sourcing Product X from Alloy, but a couple of other products are sourced from one additional manufacturer. The complexity of Product X makes the sourcing options limited, and multiple sourcing might not be plausible in this case. The second step is also including knowledge transfer and joint ventures, which both are present to some extent even though they both can be improved.

Supervising suppliers is the third step in the hierarchy by Liker and Choi (2004). More profound collaboration activities where senior managers are involved often become time-consuming, and in a fast-growing company as BIOP, the time is of the essence. The supplier relations have not been prioritized in the organization. A standardized communication is not applied, and contact is only initiated when issues arise. Since the second step is partially achieved and the third is not, the following steps are not of focus for BIOP. However, if a standard for communication is achieved and BIOP allocates more time towards supplier relations, the next step is to help Alloy and other suppliers building their technical capabilities. As Alloy is a considerable small manufacturing company, it could take advantage of knowledge and capabilities possessed by personnel at BIOP. This includes especially management techniques and methodologies for streamlining the production. A similar commitment by BIOP could increase the reliance and trust, making Alloy confident in the relationship. This would open up for more transparent information sharing as desired in step five. The last step is a more extensive collaboration of improvement activities, and this requires confidence that both parties are aiming for a long-term relationship and have the best intentions for the collaboration. Even though BIOP's relationship with Alloy is stuck between step two and three, the improvements and possibilities to climb in this hierarchy are ought to be within reach.

5.5 BIOP'S SUPPLY CHAIN STRATEGY

As mentioned by Lee (2002), a company is recommended to manage its supply chain based on several factors, such as the business strategy and the demand for the product. Alloy has a somewhat unpredictable demand since the company receives irregular forecasts from BIOP, which sometimes are revised. In a situation like this, when there exists uncertainty in the supply chain because of insufficient information flow, either a physical function or a market mediation function could be emphasized (Marshall & Fisher, 1997). The supply chain examined in this project corresponds to an innovative demand, which calls for market mediation. The SCS is constructed in a way that ensures that the produced products match the customers' demand. A mediation function can, though has consequences for the parties involved in the supply chain, for example, by risking lowered efficiencies when adjusting production to match actual demand (De Treville et al., 2004). This is present at Alloy, who adjusts the production because of unreliable forecasts, and lost communication.

Demand- and supply chain integration is vital for the supply chain in question to improve because both integrations are currently missing in terms of visibility, planning, information sharing, efficient delivery, and logistic communication (Frohlich and Westbrook, 2002). As BIOP was identified as a company with a mediation function, the literature suggests that BIOP should focus on demand integration. Demand integration mainly supports the transfer of information about changing customers' needs, and thus facilitates a faster response to the changing demand.

5.6 REDUCING LEAD TIME WITH INCREASED SUPPLIER INVOLVEMENT

The actual lead time for Product X was proven to have significant fluctuations during the studied time period and could be determined to vary from 8 to 13 weeks. The main drivers in the lead time were identified to be connected with the extended time at Alloy's suppliers, but also on the reoccurring quality issues detected after coating at Alloy. According to Hopp et al. (1990), it is essential to reduce variability in production, concentrating on minimizing rework and reclamations through more continuous quality control during the production process. Therefore, BIOP, together with its supplier, needs to work more on further improvements in quality instantly. Alloy needs to prioritize to reach the projected lead time and reduce cycle time to achieve customer pleasure (Siva et al., 2020). Likewise, delivering the articles for Product X on time and incorrect quantities are vital factors to stay competitive. The throughput time is also essential to focus on, as presented by Tersine and Hummingbird (1995), which insist that it should be decreased by prioritizing lead times activities according to the TOC approach.

From the interviews, it became clear that rework and reclamations are frequently occurring at the parties in the supply chain. Alloy has because of this reason increased the number of quality controls during its production process, which is a suggested method to reduce variability in production by Hopp et al. (1990). However, the opportunity for reducing lead time starts with the product development team at BIOP, which are responsible for the product conceptualization. CE is one concept that can be of a strategic response to the reduced lead time (Tersine &

Hummingbird, 1995). Communication and involvement between departments are crucial to achieving a parallel design, and the involved parties in the supply chain should, therefore, make improvements in this direction. Insufficient coordination is not only present in this research, but a normal state in most businesses. If BIOP and its supplier adopted CE in the best way, they would start to share information early to receive valuable input from the suppliers. Boston et al. (1998) and Culley (1999) argue that there often is a lack of guidelines for how and when to communicate and, therefore, seldom happens early in projects. Currently, Alloy receives a new design or construction relatively late when BIOP already has invested much time and resources. Hence, Alloy experiences that it limits the opportunity to bring significant value and input in the development phase. For BIOP to successfully improve its interaction in the design phase with Alloy it would need to introduce guidelines to communicate with its suppliers regularly.

The supplier and the buyer in this case study optimize their functions independently, and apart from the order quantity, it does seldom exchange any further information. The optimal situation would be when one decision-maker chooses the optimal decision that yields minimal expected total cost for the entire supply chain. To be able to coordinate this mechanism and make decisions that are collectively favorable, further information exchange between the two parties need to be taken. Increased interaction between firms can further create conditions for conjoint innovation since few firms usually do not possess all resources for development in-house, and thus need to require supplier interfaces (Lind & Melander, 2019; Yeniyurt et al., 2014). If Alloy was involved in BIOP's NPD, it would not only result in performance returns for BIOP, but also for Alloy since it increases the performance of both.

An interrelationship between network connectivity and the quality of innovative ideas is presented by Björn and Magnusson (2009), which indicates that BIOP should increase its connection with individuals at the suppliers. This is also confirmed by Yeniyurt (2014); external collaboration is shown to increase productivity, improve product quality services, obtain access to new markets and technologies, and reduce costs. Because of those reasons, BIOP would advantageously establish external collaboration and innovation. With regards to Yeniyurt et al. (2004), the process of establishing an innovative, collaborative relationship is attained when certain requirements are achieved. Examples of this are when the supplier trusts the buyer, and positive attitudes towards co-innovation are present from both parties. As stated in this report, BIOP and Alloy have increased their dependence on each other. Supplier dependence is a necessary element when performing collaborative NPD, according to Yeniyurt et al. (2014). The dependence creates an incentive for involving the supplier in NPD, and consequently achieving a more suitable product for the supply chain. However, dependence also makes it difficult for one party to end the relationship. It would be costly for BIOP to change suppliers due to the information and expertise that Alloy possesses. Moreover, Alloy's specific investments and production adjustments create a moat for terminating the collaboration and creates a desire to continue exploiting the investments already made. The longer the relationship progresses, the higher the barriers become for ending the relationship.

6. RECOMMENDATIONS

This chapter aims to provide some distinct and practical recommendations to the involved parties. The chapter is divided into two parts. Firstly, recommendations to reduce the lead time are presented. Secondly, recommendations that are connected to the lead time, but not resulting in reduced lead time will be depicted.

6.1 LEAD TIME RECOMMENDATIONS

The following seven recommendations are intended to enable improved lead times and a sufficient supply of goods, essentially answers to the stated Research Question. These recommendations are believed to enhance the organizations' success, prevent the recurrence of quality problems, and consequently reduce the lead time. The first five recommendations are intended to be successfully implemented within a year, and the last two are believed to demand more effort and time before showing any improvements in lead time. The recommendations are also presented in a prioritization order suggested by the authors, this is decided based on the impact of the recommendations and the difficulty in implementing them.

6.1.1 INTRODUCE A ROUTINE FOR PRE-BOOKING

Based on the findings from the study, the need for pre-booking deliveries at the sub-suppliers is vital to facilitating lead times and achieving an adequate supply of goods. A considerable amount of lead time is located at sub-suppliers; 17 of 35 days for the most complex article (A), and for less complicated articles, the proportion is even higher. Hence, Alloy must pre-book deliveries at Coat to optimize lead time and ensure deliveries in time to BIOP. It is desirable for Coat to receive the pre-booking at least four weeks before the coating starts, but preferably as early as possible to allocate time in the production schedule. As expressed by Coat, the lead time for coating could be reduced by 50%, from ten to five working days if Alloy started to pre-book its orders. Although, it is important for Coat to also respond to Alloy's pre-booking and confirm that the scheduled date is possible, and that Coat has available resources for Alloy's products.

Alloy would also benefit from pre-booking at Anode since this implementation could shorten lead time for anodized articles. It is recommended that Alloy start a dialogue with Anode to investigate the possibilities for reducing the lead time by pre-booking all deliveries. Currently, Alloy provides no premonition or pre-booking to help Anode prepare and schedule its production, and the current confirmed lead time at Anode is between ten to twelve working days. The authors believe the work could be done faster if Anode has time to plan orders beforehand.

Pre-booking can also be reviewed for Clean Surface. Based on this research study, the need for pre-booking could be even more beneficial for Clean Surface since more or less every article is processed through the firm's cleaning process. A dialogue should start to investigate if any possibilities for lead time reduction are available. The routine can preferably be applied to all suppliers when the process is going smoothly at Alloy since the barriers would decrease to do the same thing with others if a routine has been established.

6.1.2 MONITOR INTERNAL QUALITY

Currently, BIOP is not informed about internal complaints at Alloy. Monitoring of internal complaints at Alloy would favor the collection of possible problems that contribute to the increased lead time for BIOP's deliveries. The interviews implied that BIOP would like to have an improved overview and understanding of Alloy's internal reclamations since they are believed to result in extra time, costs, and lead time. Working with the registration of internal problems can give Alloy a basis to share with BIOP for the buyer to understand the additional cost in production, and also enable the possibility to work together with rising quality problems. Therefore, sharing information from collected statistics about internal problems is believed to be an essential facilitator for useful improvement and elimination of problems, and for optimizing cost and lead time.

6.1.3 ELIMINATE THE ROOT CAUSE FOR COATING PROBLEMS

Alloy has been the producer for Product X since the start of production. Despite the time BIOP and Alloy have collaborated, the problem with coating and quality has never been solved. It is recurring problems with almost every delivery, which are identified in the final quality inspection. According to the Quality Controller at Alloy, 10-20% of article A needs to be sent back to Coat for reworking. However, it is not clearly stated what causes quality issues and where they derive from. Even if the problems are mostly detected after the coating, there can still be other steps in the production process that cause the problems. Before the final inspection, the problems should be detected if the causes for deviations are mapped and understood. Alloy needs to investigate this problem and execute a root cause analysis to find out where the problem arises to be able to eliminate it. Alloy should start investigating which different reasons for coating problems exist, and by using internal statistics of the causes, start eliminating reasons one by one. If the root cause is found and can be resolved, the lead time will dramatically decrease and thus empower deliveries in time. Even though the achievement of total prevention may not be possible, a root cause analysis of the coating problem can be seen as an ongoing process that yields continuous improvement for the company. It will allow Alloy to identify barriers and the causes of problems, hopefully resulting in permanent solutions.

6.1.4 USE EXTENDED AND REGULAR FORECASTS

During this project, it has become clear that all parties involved are dissatisfied with the communication and forecasts about deliveries presented by BIOP. Therefore, BIOP is recommended to communicate clearly about any deviations from its plan and forecast. BIOP can preferably give information about revisions and changes continuously. A system for communicating and updating BIOP's current status and sharing this information through the supply chain should thus be implemented. Frequent documentation review will reduce the administration time before Alloy starts production since it will be up to date when new orders arrive. This can reduce the lead time with more than a week if orders are confirmed directly by Alloy.

Forecasts can preferably be shared with suppliers and sub-supplier once a month, and eventually, circumstances that affect the forecast considerably must be announced additionally. The forecast

would beneficially involve the current status of inventories, future demand, plans, sales progress, and finally, new products and projects that affect the supply chain. The supplier understanding can increase if BIOP can be more transparent in its underlying demand and storage levels. As a result, the lead time could be improved since Alloy can arrange its supply based on BIOP's forecasted sales. Alloy could thereby allocate time in production and also personnel if demand is forecasted. Moreover, Alloy's knowledge about BIOP's priorities can expand if the company is informed on current inventories at BIOP, and Alloy can speed up deliveries accordingly in advance.

6.1.5 REVIEW OPERATIONAL PRIORITIES

The five performance objectives cost, speed, dependability, flexibility, and quality are established as a trade-off scenario where not all can be achieved to the same extent, and each organization needs to make its priorities. BIOP has been trying to achieve nearly all objectives simultaneously when working with its suppliers. Achieving all objectives at the same time creates an almost impossible situation for the suppliers as they have unreachable demands from BIOP on the products and deliveries. Therefore, BIOP should revisit its operational priorities and decide on which performance objectives are the most valuable ones and where the focus mainly should be placed. Otherwise, trying to achieve everything at the same time often results in achieving nothing at all. Quality and cost are a well-known trade-off, and as BIOP strives for superior quality, it is also expecting low cost and constantly questioning and challenging Alloy's prices. Those expectations create a problematic situation for Alloy, making it difficult for Alloy to deliver and satisfy BIOP. Furthermore, Alloy insists the work executed is craftsmanship, and to get the best product, it will require more time.

It is reasonable for BIOP to communicate the decided priorities clearly to Alloy. Quality has been communicated as the most critical delivery objective. Therefore, it is essential to realize that high quality requires more time and costs more money. However, if speed is a priority, quality might need to be sacrificed to achieve shorter lead times. Achieving higher quality might require more advanced and time-consuming production steps, as well as extra quality inspections to ensure the quality requirements are fulfilled. An example of this is the surface treatment process located at Clean Surface, which was introduced to achieve the high coating requirements demanded by BIOP. If BIOP would prioritize lead time and lower its quality demands, this process could be removed and significantly reduce the lead time. To summarize this recommendation, BIOP should revisit its operational priorities and evaluate if the quality is the ultimate performance objective, and if this still is the case, extended lead times are inevitable. This conclusion does not mean that the lead time can not be reduced, only that longer lead times are a consequence of high-quality expectations.

6.1.6 COMMIT TO A LONG-TERM RELATIONSHIP

This research has acknowledged that Alloy is uncertain about BIOP's commitment to their future relationship. The effect of this is, first of all, limited information sharing. Due to the uncertainty of the future, Alloy is not willing to share information that could exploit its informational power with BIOP. This unwillingness has, for example, limited the information sharing in this project, since Alloy expressed concerns that the information could be used by BIOP to replace Alloy.

Another effect depending on the lack of commitment, is that Alloy is less willing to invest in the relationship because of the uncertainty in the returns of the investments. One example is that Alloy could invest more in equipment and tools, making the production of BIOP's products more effective and, in that sense, reducing the lead time.

BIOP has, during this research, expressed a desire for a long-term relationship between Alloy and BIOP. If a more in-depth relationship is desired, BIOP needs to initiate the first step towards this by showing support and trust for Alloy. Therefore, the authors suggest that BIOP increases its efforts in making Alloy more confident in the future of their relationship. An improved relationship can be achieved, for example, by an agreement of production between Alloy and BIOP, an investment from BIOP in Alloy, or a joint venture where both companies invest time and money to continue developing their relationship and products. It is also essential that BIOP can do this without making Alloy too confident in the relationship, leading to less engagement in the development and improvement of its production. To counteract this, the authors of this report suggest incentives and motivation used by BIOP to encourage Alloy to devote time and resources to developing its production and relationship with BIOP. Essentially, replacing fear as motivation with encouragement.

Achieving more trust in the relationship enables more sensitive information sharing. Alloy could then apply the open-book theory to share cost and production data with BIOP. Sharing data could enable a deeper collaboration for reducing costs and facilitate a mutual understanding of how to make the products more cost-effective. By reaching a more profound understanding, BIOP could also be more aware of what is causing the lead times, and in collaboration with Alloy, help reduce them. Likewise, if Alloy was confident of the future with BIOP, it would be more willing to produce a safety stock to supply BIOP. Hence, this recommendation implies both increased delivery precision and reduced lead time.

6.1.7 EARLIER COLLABORATIVE DEVELOPMENT

Quality issues have shown to harm the lead time between Alloy and BIOP. Numerous reworks and rejected products extend the lead times and also result in reduced delivery precision. Many of the quality problems can be reduced by considering the production aspect early as in the design phase. This concept is known as DFM and requires comprehensive manufacturing knowledge in the design phase. According to the literature, the design phase has been shown to stand for 70-80% of the final product quality, which also motivates additional effort and collaboration between the firms in this phase. Alloy and BIOP are currently collaborating and exchanging feedback through the product development phase. However, Alloy expresses concerns that its influence, once it is involved, is limited due to the extensive work and time that is already put into the design by BIOP. This recommendation implies that Alloy should be involved even earlier in the development phase, contacted by the designers to receive feedback on how to achieve the design desired and minimize future production and quality problems. CE can help to make the designers aware of the effect of their design choices and sometimes improve manufacturability and quality without sacrificing any design factors. This will be more time consuming, and effective NPD is crucial since BIOP is a company focusing on fast growth, and aiming to increase its market share. However, by sacrificing

some time in the development process, much time can be saved in later stages, especially when developing products aimed to be produced several years ahead. Therefore, the authors of this report recommend more extensive information sharing early in the product development phases.

6.2 ADDITIONAL RECOMMENDATIONS

During this project, it became evident that not only reduced lead time was desired by BIOP but also factors that would facilitate a more effective partnership. Deliveries in time were one of the factors desired for BIOP to allocate resources efficiently. Another evident improvement area was the communication of deliveries from Alloy. Even though this was not stated as a problem, it emerged as the main factor for dissatisfaction.

6.2.1 EXTEND THE SECURITY TIME FOR ARTICLES WITH QUALITY PROBLEMS

As stated in Section 4.2 - *Lead time* and Section 4.3 - *Delivery precision,* the difference between confirmed lead time and actual lead time is significant, and low delivery precision is a consequence. The delivery precision has, as discussed previously, been considered a reason for BIOP's dissatisfaction regarding the lead times. It has been found that Alloy uses JIT to plan its production, meaning that it will schedule for the articles to be finished Just-in-Time for the confirmed delivery date. However, a JIT approach is not typical for a producer as Alloy. JIT in literature has mainly been used in mass production with low variation and high volumes. Alloy is a contract manufacturer, which, according to the literature, is not a recommended setting for JIT. Furthermore, JIT prerequisites a high-quality production level, something Alloy has been struggling with for Product X. Alloy has continuous quality issues on several articles that are discoverable only at the last step in the production process after they have been coated at Coat. This makes it impossible for Alloy to deliver on time when these issues arise just a few days before confirmed delivery.

One recommendation from the authors is, therefore, to increase the security time in the planned throughput time for certain articles with frequent quality issues to make it possible to rework these before the confirmed deadline. This will compromise the JIT philosophy adapted by Alloy since some articles will be finished more than two weeks earlier than the confirmed delivery date. This can be perceived as a safety stock; however, the difference is that all articles on the shelves will have an underlying order and, therefore, not exposed to the risk of not being sold. By implementing this recommendation, articles with a need for rework have two weeks to be, for example, recoated by Coat. Thereby, the articles will be available for the confirmed delivery date. This recommendation will not contribute to reduced lead time; however, it will help reduce the gap between the confirmed lead time and the actual lead time. Moreover, it will increase the delivery precision and consequently increase BIOP's satisfaction.

An illustration of this recommendation can be seen in Figure 6.1 and Figure 6.2, which visualizes how the confirmed lead time constantly can be equal to the actual lead time if security time is added on articles with frequent quality problems. Nevertheless, the confirmed lead time will not be affected if security time is applied to articles that are not driving the lead time; instead, those

articles will only affect the actual lead time. By applying this approach to an article driving the lead time, for example, article A, the confirmed lead time is prolonged. However, most likely, the actual lead time will stay the same. As presented in Section 4.5.1 - *Quality*, Alloy, and Coat have agreed on a rework process for coating in a maximum of ten working days. Since most of the quality problems are connected to the coating, this extended security time allows for the products to be recoated before the confirmed delivery date. As only 6 of 30 articles have been thoroughly examined concerning delivery precision, the authors can not determine to which articles this should be applied. However, as all articles examined have considerably low delivery precision, the highest with a precision of 39%, it could indicate that security time should be applied to all articles and, in other words, abandoning the JIT methodology. Applying security time to the article driving the lead time can be seen as a trade-off between speed and dependability. It creates a longer confirmed lead time; however, it will also imply more dependable deliveries. Anyhow, the security time could be applied to many of the articles with shorter throughput time, to increase the delivery precision without sacrificing any lead time.

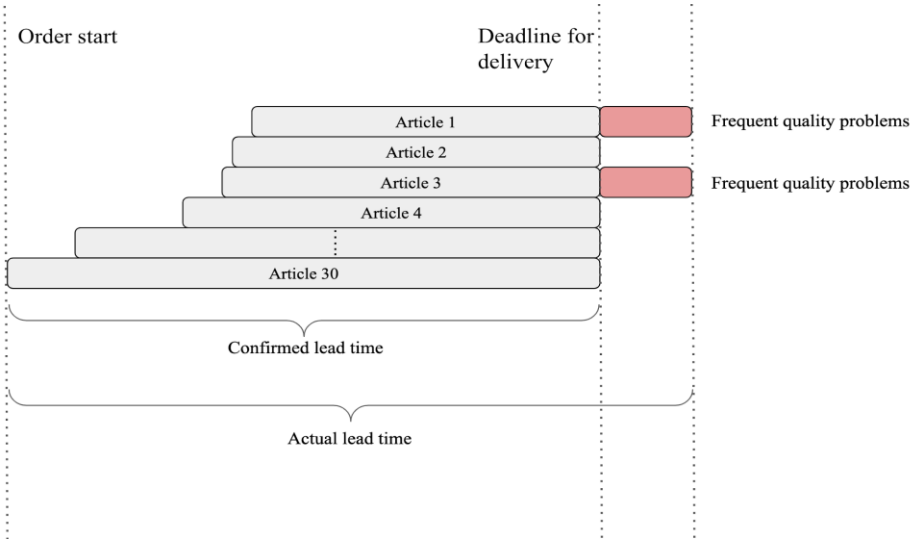

Figure 6.1: *Articles with recurring quality issues.*

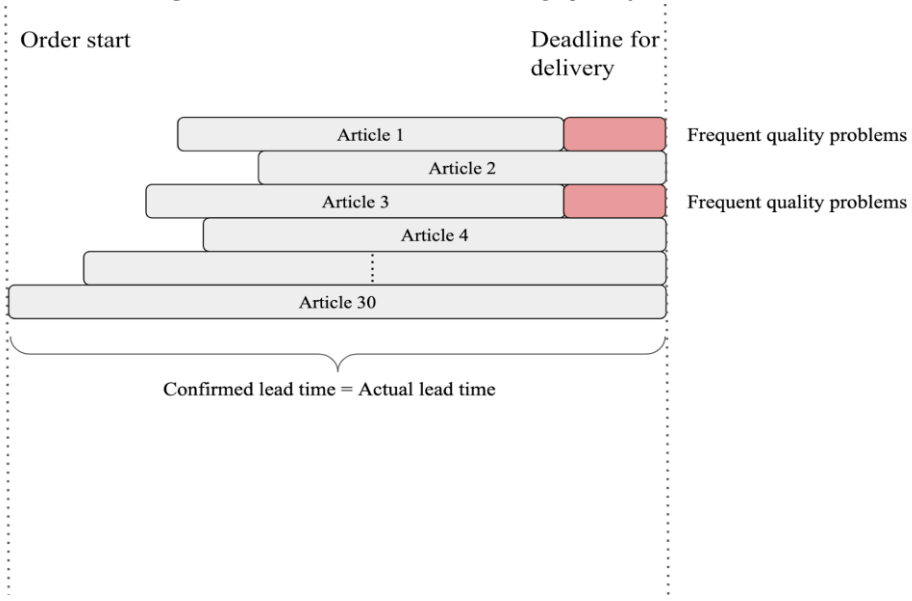

Figure 6.2: *Adding security time to articles with recurring quality issues.*

6.2.2 STANDARDIZE DELIVERY UPDATES

Currently, communication regarding deliveries from Alloy to BIOP is not frequently accomplished or informative. Alloy should start communicating delayed deliveries, reasons for the delays, and updated delivery plans for the delayed articles. This is important because BIOP needs to know how to plan its time and assembly, depending on the deliveries. Allocating personnel and equipment for confirmed deliveries is vital for streamlining BIOP's internal processes and fundamental to achieve effective resource utilization. No communication is received in the current state unless BIOP asks for information regarding the delivery or specific articles.

With more information, BIOP could help Alloy to prevent problems that limit their relationship and avoid re-scheduling. A standardized method for sharing delivery information could be implemented where, for example, the CEO at Alloy has the communication responsibility to BIOP and the employees responsible for the different departments in the firm report delays to the CEO. For example, delays connected with quality could be reported by the Quality Assurance Manager to the CEO, who then informs BIOP about the changed delivery date and the reason for the delay. Standardized delivery updates would not directly imply reduced lead times. However, it would increase customer satisfaction since BIOP can utilize its resources better and also get frequent updates on Alloy's challenges. This would hopefully result in the possibility to assist Alloy in the continuous work done for reducing the delays. This recommendation would create a more mutual understanding of the problems Alloy is facing in its production since BIOP would get more frequent updates on what is causing delays. This would also make BIOP more aware of how it in the future could ease Alloy's production by, for example, changing the design of articles to suit Alloy's production methods better.

7. DISCUSSION

A discussion about the case and the methodology of the research will be presented in this chapter. Moreover, suggestions for future research will be described at the end of the chapter.

7.1 CASE-SPECIFIC IMPLICATIONS

This section elaborates on possible implications with the specific case study in mind. Firstly, the decision to outsource and consequently balance TCE will be elaborated. Secondly, the implications with establishing an agreement in the given supply chain will be discussed.

7.1.1 OUTSOURCING OR INTEGRATING?

As stated by Kannan and Tan (2006), outsourcing helps firms to redirect their forces towards their expertise and value-added activities. However, according to TCE, increasing transaction costs forces firms to integrate previously sourced products or services inside the company's borders. BIOP has chosen to outsource the manufacturing of the metallic construction of Product X to take advantage of the expertise possessed by Alloy, and instead focus its efforts on core capabilities. As with all relationships, challenges are present, but are the challenges greater than the benefits? According to the TCE literature, this case is a subject for considering an integration. Additionally, as presented previously, the informational power and lack of confidence in the long-term relationship creates a barrier to sharing knowledge between the supply chain partners, and consequently also limits joint development and possible improvement attempts. The authors of this report believe that a commitment to collaborate is necessary, this could be a full integration of Alloy, if possible, or an alternative approach. For example, a joint venture, where both parties invest in the project to show their commitment, or an investment from BIOP in Alloy to become part-owner. However, as no further insight into BIOP's financials or priorities at executive levels were gathered, it is not possible to elaborate on how to accomplish this.

With the current setup, it seems vital for a company with high dependence on a supplier to secure this source. Integrating is one way of securing the competence needed from Alloy; however, this is expensive and diversifies from the original goal with the outsourcing. This is a dilemma that many companies are put in, and there is no definite answer, every company needs to address its organization and weigh the pros with the cons before making a decision. Switching the supplier is another alternative, when not fully satisfied with the outsourcing. This entails other alternative transaction costs, such as the search costs for finding, getting familiar, and establishing an appropriate interface with a new supplier. Furthermore, achieving the same result with a new supplier, who possesses different capabilities than the previous one could be problematic. Parallel sourcing is an alternative, which implies to secure a new supplier and ensure the quality demands can be met, before terminating the relationship with the old supplier. This technique is probably the one BIOP has used by starting a new relationship with a new supplier but not achieving the expected results and therefore returning to the original supplier.

7.1.2 COMMITMENT WITHOUT LOSING AMBITION

Creating a long-term relationship with guaranteed business transactions, without making the partner lazy was another subject that the authors found exciting and complex. During this research project, several limitations were encountered in developing the relationship due to the uncertainty of the future relationship. The supplier requested commitment and assurance of continued collaboration; however, the buyer aimed to exploit the insecurity to leverage the supplier into continued development. During this project, more negative effects of this method could be seen; as it aimed to encourage the supplier to become better, it instead showed indications of paralyzing the supplier. As solutions for this were discussed, another problem arose. A satisfactory assured supplier can quickly become unmotivated to keep developing. If the supplier is guaranteed a sufficient amount of orders every year, no motivation remains for the supplier to improve.

A way to circumvent this issue could be to include a clause into a possible agreement, terms of how the supplier should perform or improve in order to keep the orders. If the supplier is not fulfilling the terms, the buyer has the opportunity to terminate the agreement and search for alternative suppliers. Nevertheless, this once again comes with some complications. The transaction costs will increase. Firstly, by the negotiation and creation of the agreement between the two parties, but since this is a one time action, it is not a deal-breaker. Secondly, the policing costs will increase since the buyer needs to ensure that the agreement is fulfilled. The authors believe that easily measurable metrics are the key to success, metrics that can be monitored frequently without increased resource usage.

7.2 DISCUSSION OF METHODOLOGY

In this project, the methodology consisted of several different steps aiming to answer the research question. When conducting qualitative interviews, there is a risk that the researchers will steer the interview to confirm previously conceived notions. This risk was dealt with by asking open questions, enabling the participants to interpret the questions in their own way. The research methods used have facilitated a successful project and enabled the researchers to arrive at recommendations answering the stated Research Question. Since the research could be categorized as exploratory, there were no maps for how to exactly reach an answer to the question. Instead, the possibility presented themself along the way, and the authors iteratively reviewed literature and scheduled new interviews based on the findings presented.

One improvement area for the research is recording and transcribing the interviews, however, this was considered from the start and continuously reviewed. The researchers' perception was that the participants were already restrictive with information sharing, nor used to be part of a research project like this one. Therefore, a trade-off was presented, since a higher quality could be achieved by recording the interviews, but believed to restrict the information sharing. The researchers decided not to record the interviews and instead use extensive note-taking, and the same decision would have been taken if the project were repeated. Moreover, there exists a risk that information can be neglected during interviews and not correctly captured. The researchers mitigated this risk by always reviewing notes directly after the interviews, correcting, and adding information to the notes.

The research quality can be assessed with the previously presented framework by Bryman and Bell (2011). Trustworthiness is the first assessment area and is split into four categories; *credibility, transferability, dependability,* and *confirmability*. The *credibility* of the findings is considered to be satisfactory. However, as in all qualitative research, much of the data collection consisted of opinions from the research participants. The researchers have tried to absorb the information and make unbiased decisions, always trying to confirm one statement with another source. If possible, statements were also confirmed with quantitative data. *Transferability* is further believed to be achieved since the limited population, and the comprehensive data collection contributed to accomplish transferability. However, most of the interviews were held with people at senior levels, so opinions and data collected might not represent everyone's opinions. *Dependability* is also considered to be accomplished by continuous revisions of the methodology to ensure it was possible to follow. The authors have used outside counseling to review the methodology and received feedback on it continuously to make sure it is traceable. *Confirmability* is the last category of trustworthiness, and a concern was made early in the project regarding the fact that BIOP employed the researchers. This entails a risk that the authors become biased in their research. The authors might focus their efforts more towards the supplier to keep the employer satisfied, instead of presenting the unbiased results. This concern was brought to the authors early in the research and something that continuously has been reviewed.

The second assessment area of the framework proposed by Bryman and Bell (2011) is authenticity and is divided into five categories; *fairness, ontological authenticity, educative authenticity, catalytic authenticity,* and *tactical authenticity. Fairness* has been achieved as the researchers have aimed to reach a nuanced view of the problem and tried to involve similar representatives at all stakeholders. However, the information sharing has been more generous from some stakeholders, resulting in a partly tilted sourcing of information. *Ontological authenticity* implies an improved perception of the studied environment, and this has been achieved by introducing new phenomenons to the supply chain partners, also confirming known phenomenons from an outside actor. This research has also educated the supply chain partners to understand each other better, independently presenting their thoughts for one another, resulting in *educative authenticity*. Furthermore, the research has provided practical recommendations that motivate the participants to implement these in their environment, hence *catalytic authenticity* and *tactical authenticity* are reached.

7.3 FUTURE RESEARCH

This case study aimed to improve the lead time for Product X, and an analysis of historical delivery data to investigate the problem was executed during the project. However, only 6 out of the total of 30 articles were analyzed and included in the report. To further gain insight in the outcome of previous deliveries from Alloy to BIOP a more extensive analysis of delivery data can be performed, including all the articles of Product X. This would result in a better general picture of the situation and an understanding of which articles are the most critical ones.

Further, this study was limited to investigate interfaces between Alloy and its sub-suppliers, and it was not possible due to circumstances to examine distinct internal processes at Alloy. If Alloy approved data collection in the production, it would result in an extensive mapping of processes and waiting time, and thus enable the possibility for identifying improvements in the production. Thereby, the internal lead time could be further improved, and the production optimized.

Another interesting topic to investigate is the source of coating problems in Alloy's production. Alloy and Coat have together investigated this, but have mostly been using preventive methods to mitigate the effects of the coating problems. Improvements have also been made to reduce the number of problems, but it is still a significant problem for the lead time. A project with the aim to map and understand all root causes for the problems could be employed to solve this jointly. This requires a mutual commitment and openness between the firms in order to succeed.

Lastly, the internal communication and collaboration between departments at BIOP would be interesting to investigate further since it has been found during interviews that more intensive communication is desirable. BIOP is a relatively young company with rapid growth and has not had much time to focus on improving its internal processes. In the current state, there are no natural communication channels to use between the product development team and the procurement department. Hence, this could be a possible subject for further research.

8. CONCLUSIONS

In this chapter, the research question will be answered and explained. Furthermore, additional conclusions will be presented as well as notions of how the literature has contributed to this case study.

Research Question - How can the lead time for Product X be improved?
The lead time for Product X was determined in Chapter 4 - *Empirical Findings*, whereas the confirmed lead time and the actual lead time, was presented, and a distinct difference was acknowledged. Based on the literature review, and to a great extent, the answers provided from the interviews at the case company and the connected suppliers, several improvements for the lead time could be identified. These were;

1. Introduce a routine for pre-booking,
2. Monitor internal quality,
3. Eliminate the root cause for coating problems,
4. Use extended and regular forecasts,
5. Review operational priorities,
6. Commit to a long-term relationship,
7. Earlier collaborative development.

These recommendations could be divided into both short-term and long-term solutions for reducing the lead time. The first five recommendations could preferably be implemented within a year, and the two remainings require more time before contributing to reduced lead time.

The authors also identified improvement areas, not corresponding with the stated research question. However, they were too critical not to address. These were; (1) extend the security time for articles with quality problems and (2) standardize delivery updates. Since these recommendations will not contribute to reduced lead time, they will instead provide valuable improvement to the relationship and enhance the satisfaction of transactions between BIOP and Alloy.

Through these recommendations, the authors believe that the aim of this research project has been fulfilled and will help guide the case company and its supplier to reduced lead time, as well as providing information on how to improve their collaboration further. This thesis also provided valuable insight into how to use established literature theories and apply them to a specific problem. For example, the theory of TCE has been applied to describe the complex process of transactions between firms. Moreover, several theories for supplier relationships have been used to describe the constant difficulties in achieving a mutually successful relationship between a buyer and a supplier.

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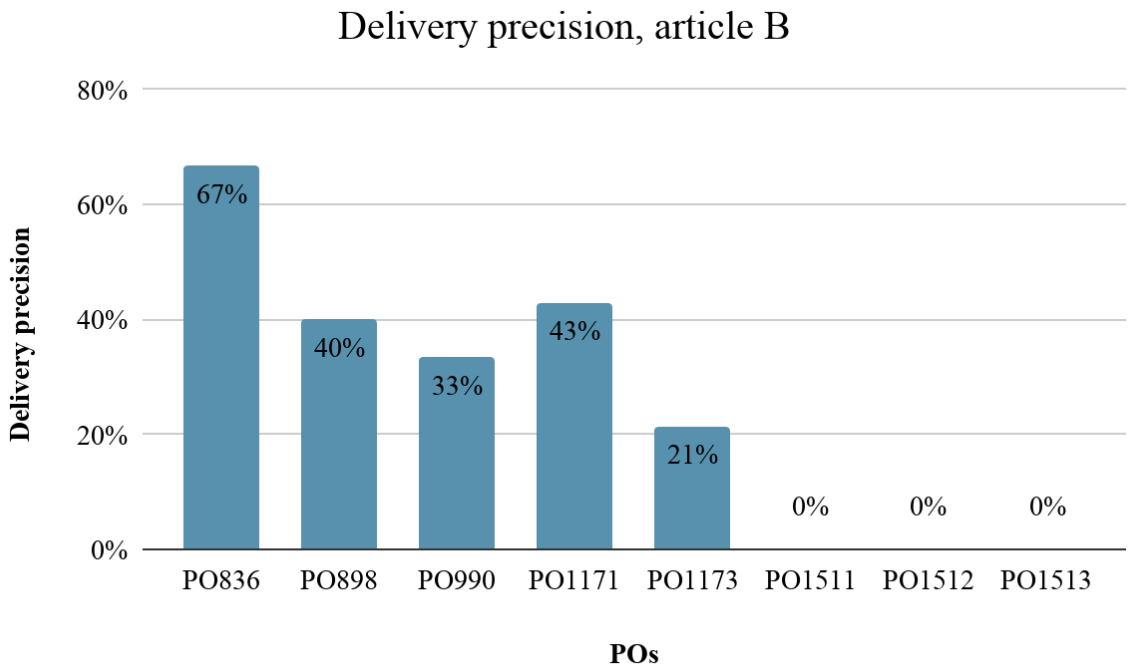
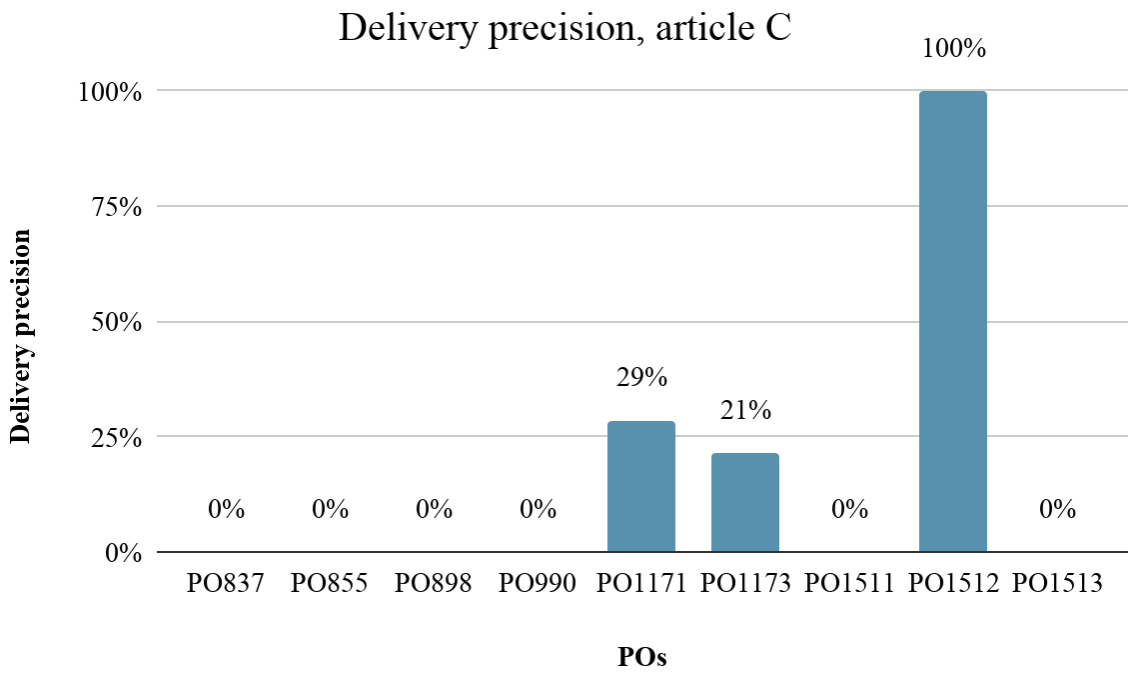
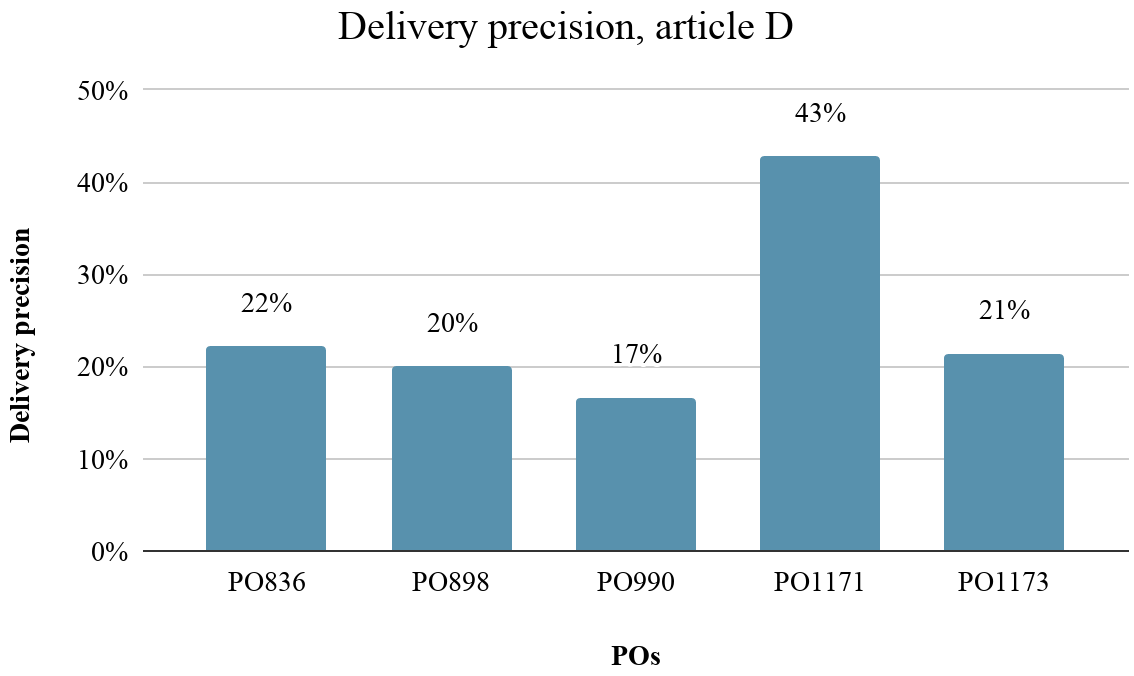
APPENDIX A

A.1 DELIVERY PRECISION



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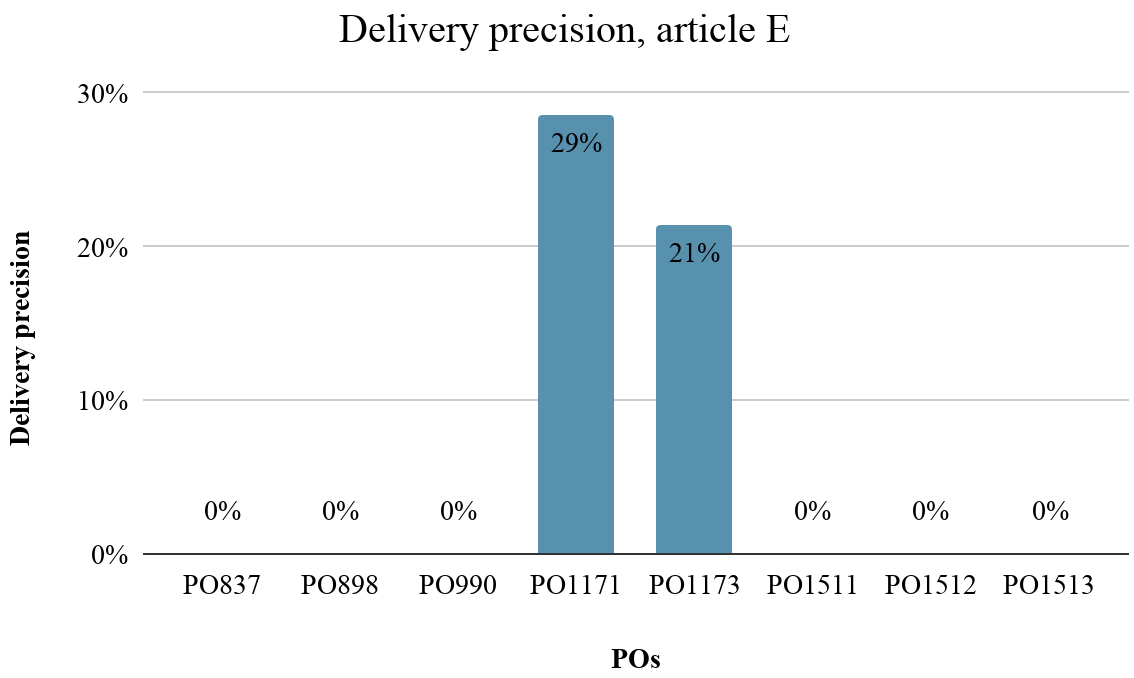
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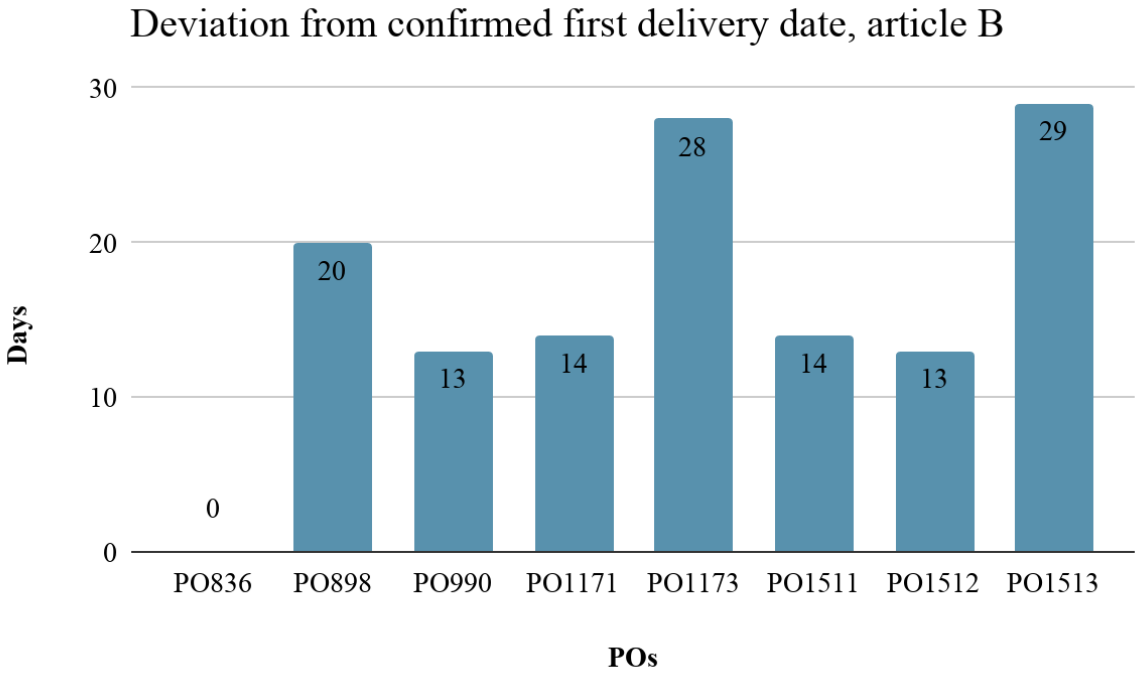
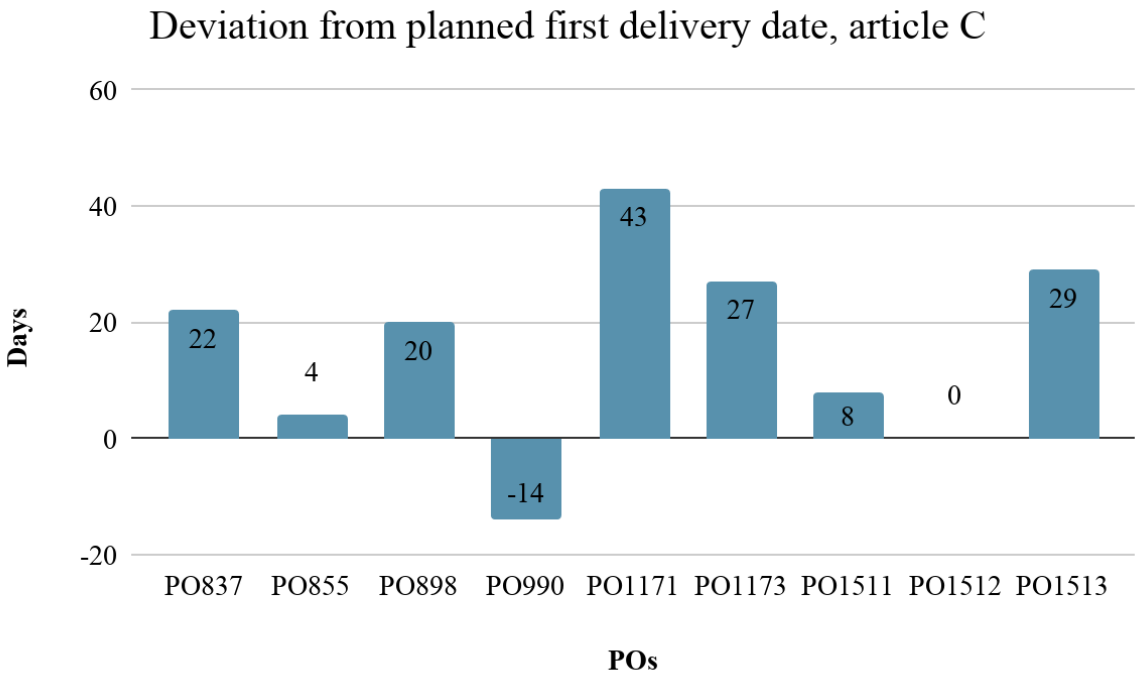
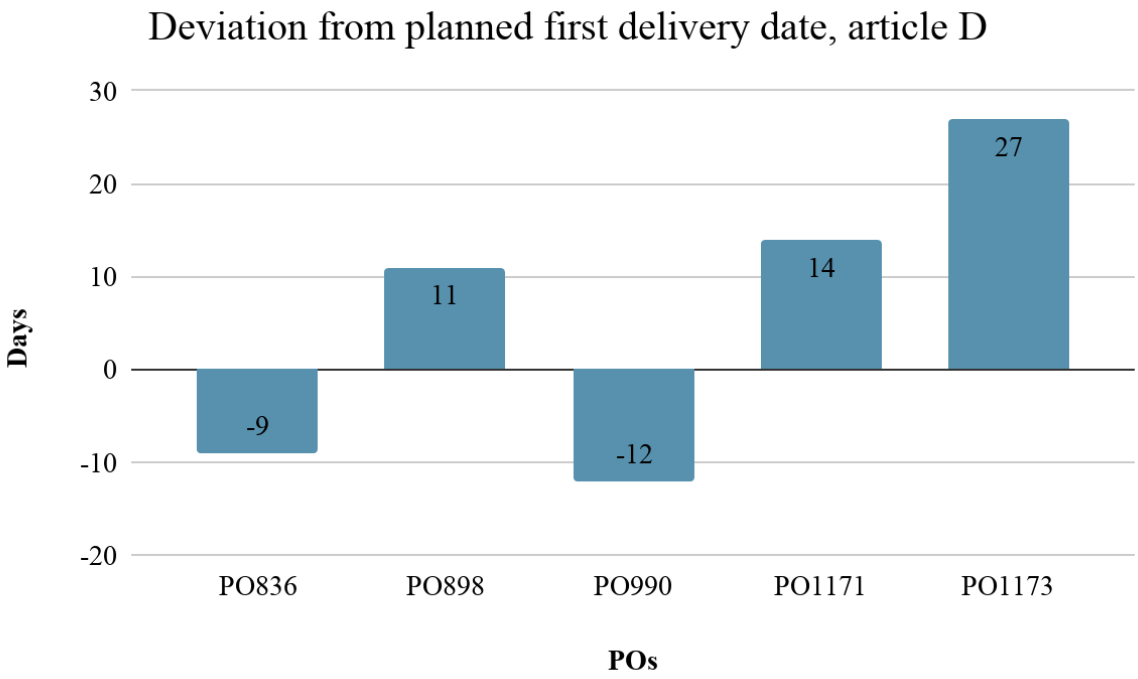
A.2 DEVIATION FROM CONFIRMED FIRST DELIVERY DATE



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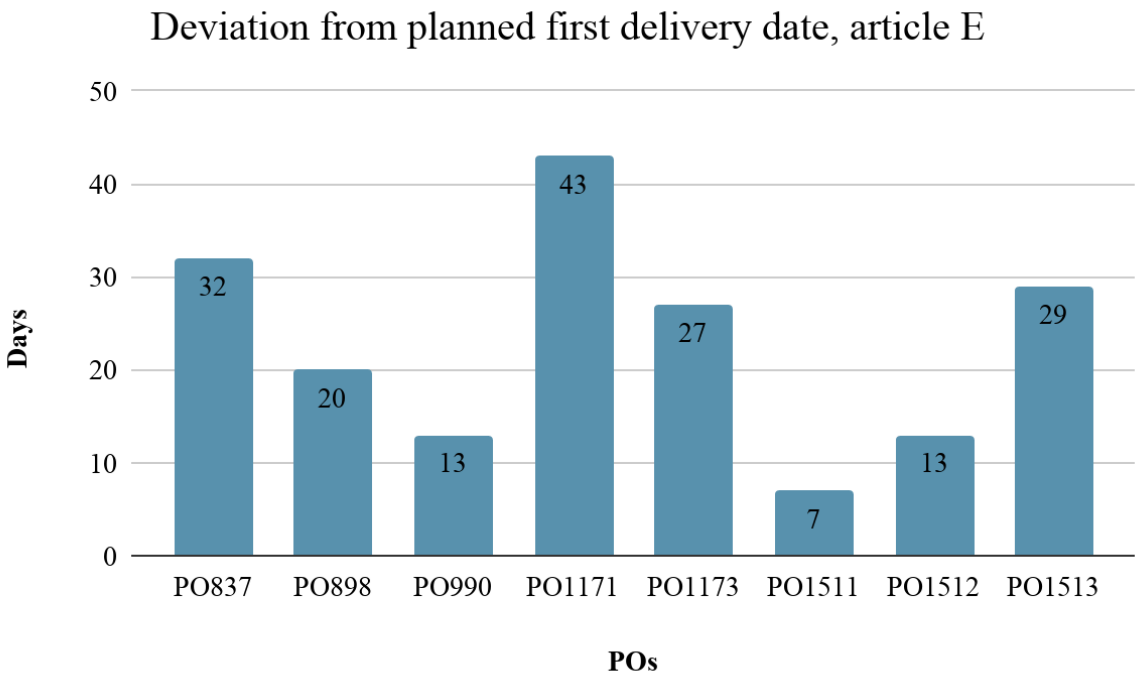
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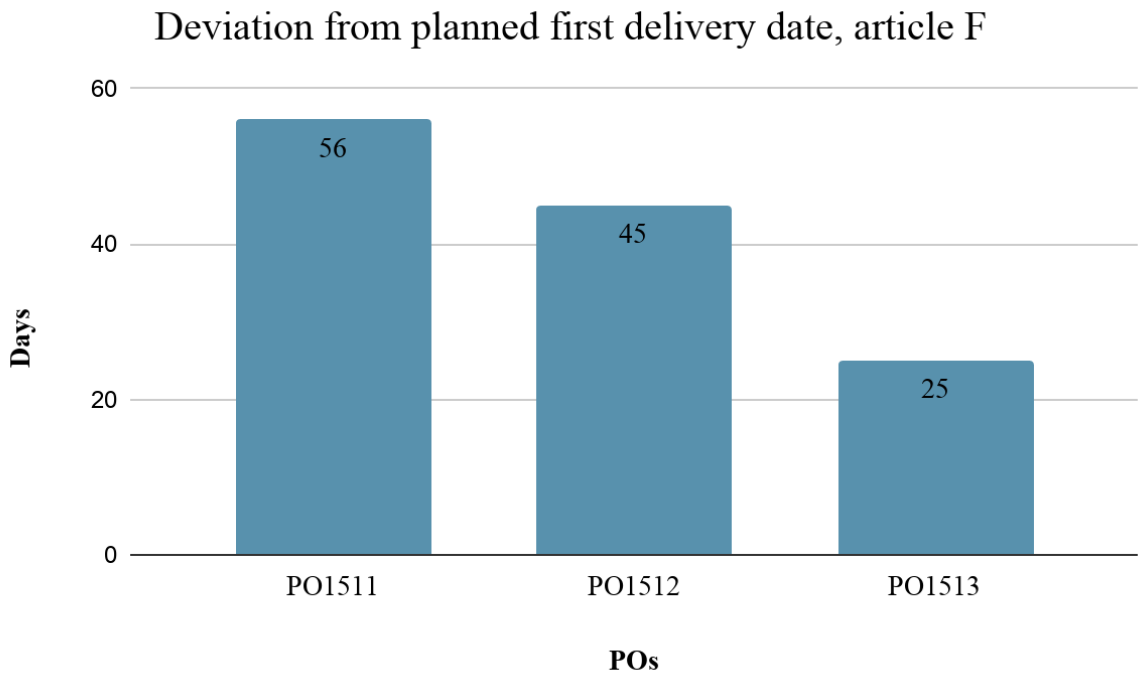
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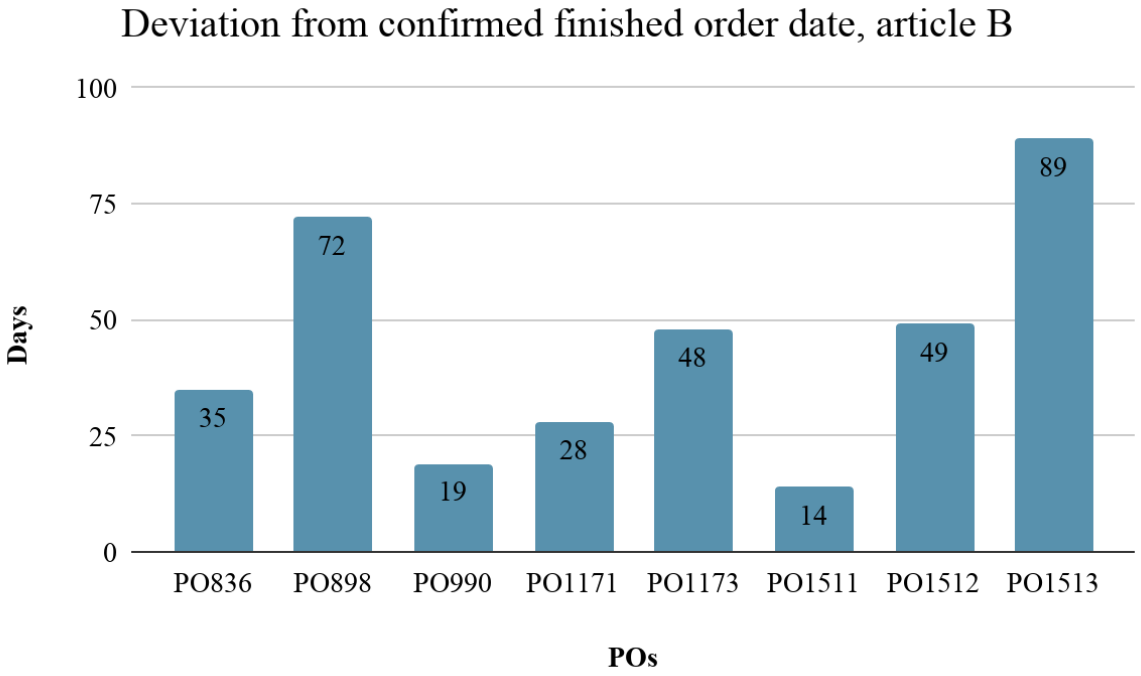
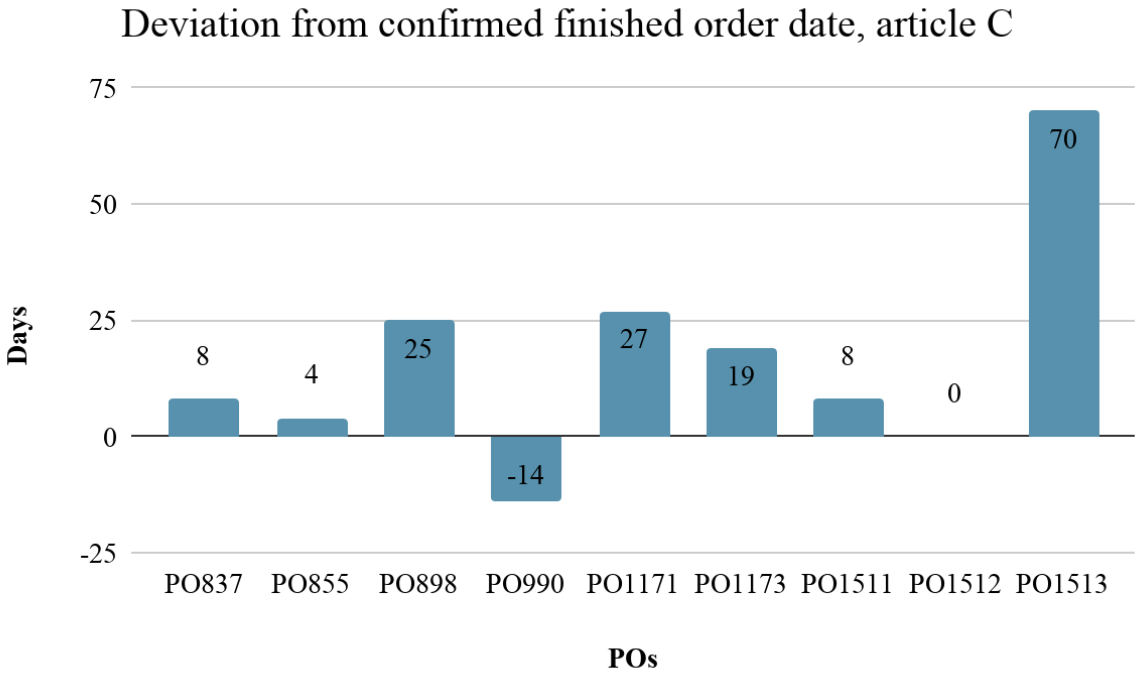
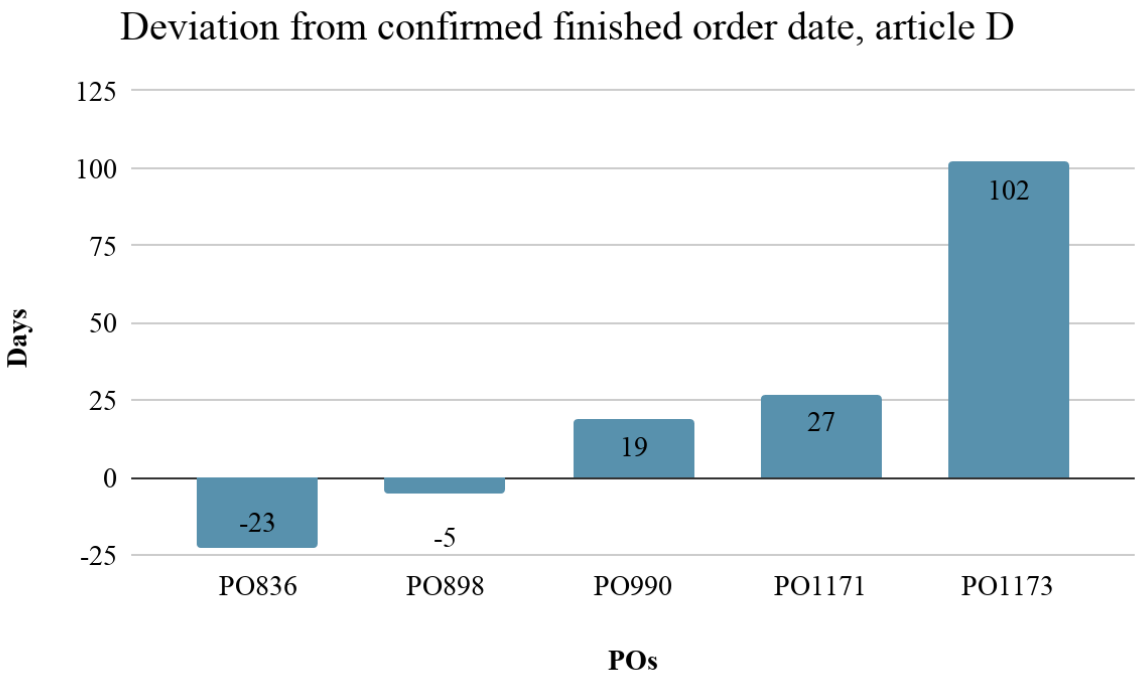
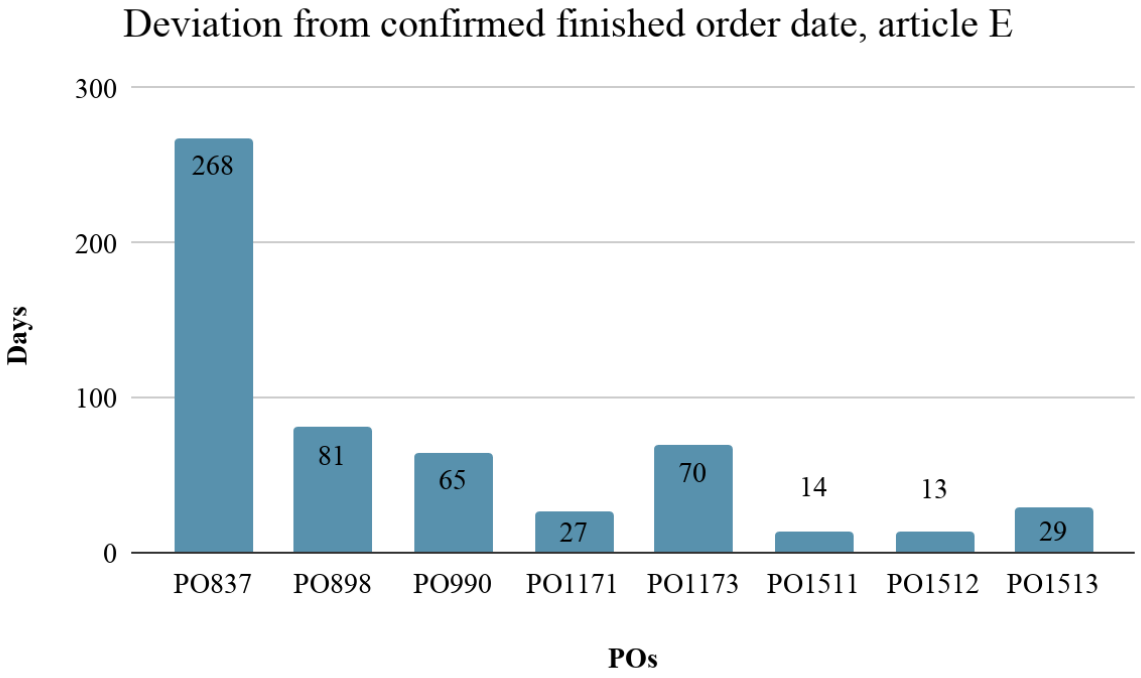
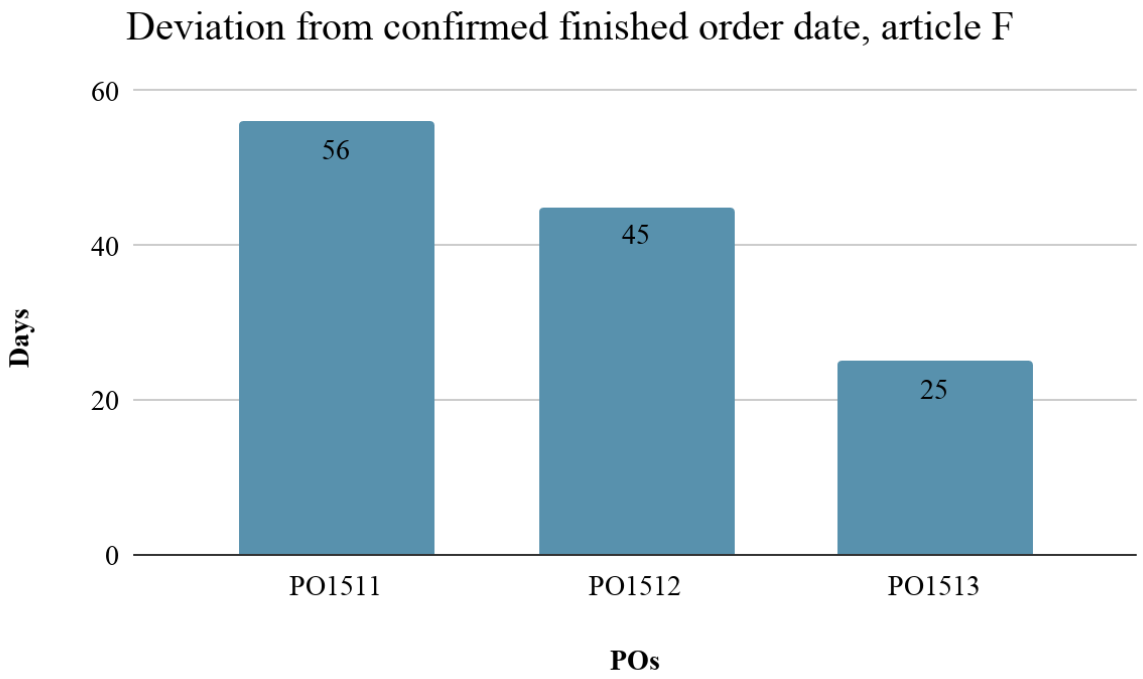
A.3 DEVIATION FROM CONFIRMED FINISHED ORDER DATE






Deviation from confirmed finished order date, article D
125
100
75
50
25
0
-25
Days
-23
-5
19
27
102
PO836
PO898
PO990
PO1171
PO1173
POs


Deviation from confirmed finished order date, article E
300
200
100
0
Days
268
81
65
27
70
14
13
29
PO837
PO898
PO990
PO1171
PO1173
PO1511
PO1512
PO1513
POs


Deviation from confirmed finished order date, article F
60
40
20
0
Days
56
45
25
PO1511
PO1512
PO1513
POs

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