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Automation in purchasing order through items classifications: a case study in Finland

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To cite this article: Tomi Juhala & Ahm Shamsuzzoha (08 Dec 2024): Automation in purchasing order through items classifications: a case study in Finland, Supply Chain Forum: An International Journal, DOI: [10.1080/16258312.2024.2399501](https://doi.org/10.1080/16258312.2024.2399501)

To link to this article: <https://doi.org/10.1080/16258312.2024.2399501>



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Published online: 08 Dec 2024.



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Automation in purchasing order through items classifications: a case study in Finland

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ABSTRACT

The aims of this study are to analyse the procurement process of a case company in Finland and to find ways to improve both the inventory level and purchasing efficiency. This study adopted both theoretical and empirical methodological approaches. In the theoretical section, it presented various models of modern purchasing and inventory management principles, whereas, in the empirical research, it is presented an implementation of an XYZ-analysis extension for the case company's current ABC analysis. In this research, the case company's year of worth of inventory requirements from six selected suppliers are analysed to create an ABC-XYZ matrix that is refined to a set of inventory management rules. The results from the ABC-XYZ analysis and the created matrix of rules, a proposal for an automated process with system suggestions is presented in this study. This automation system is based on the idea that low value items that have low number of fluctuations in their production demand can be automated to reduce the purchasing workforces. The study is concluded on the idea that the case company has the capabilities to implement an automated system basing on its current system capability, but it requires building new processes and purchasing or building a new supplier system to fulfill the proposed workflow.

KEYWORDS

Items classification; automation; procurement; purchasing process; supply portal; Finland

Introduction



Operational purchasing is a core operation in production companies. Purchasing takes care of continuous communication between suppliers and the company, ensuring economically smart inventory levels with calculated and forecasted purchasing and are largely responsible for upholding the quality of master data in the systems used for purchasing such as ERP (Enterprise Resource Management) (Chicksand et al. 2012; Tummala, Phillips, and Johnson 2006). In modern management, the quality of purchasing has risen to be one of the more important parts of the supply chain, which is why new better managerial and digital tools have been created to ensure that purchasing decisions are systematically controlled and economically justifiable (Juhala 2021; Pereira, Christopher, and Silva 2014).

This study was brought up to a case company, an electronics manufacturer residing in Southwest Finland. The company's main products are cable signal amplifiers used in TV and internet infrastructure. The materials for all the product lines consisted of thousands of different item codes from over a hundred suppliers worldwide. Just making the purchase orders and handling the orders is a very time heavy process that involves 10 purchasers and material planners at the case company. While its operational purchasing has many aspects of the process

that can be considered advanced and optimised. The case company has found a few parts of the process that they feel make the purchasers' job too tedious. Since the process is so heavy to begin with, company's management feels it is important to save the purchasers from doing simple input tasks and try to focus their tasks on more value-adding work. This study comes with business implications, with the automation of low value items in the inventory, purchasers get to put more focus on the high-value inventory and in lowering their safety stocks and so their inventory values.

The point of this study is to analyse the existing purchasing pipeline and parts of the workflow with the intent of providing optimisation propositions and in the end creating a framework for implementation of new processes. This study is conducted with the idea that the case company is aiming for a completely or at least a semi-automated purchasing workflow, where very minimal human input would be required in tasks that have low operational value. This would allow allocating workload to value-adding work that has more value, making the work more pleasant and making the process more economically optimised.

The case company has already uncovered the parts of the pipeline it wants to be addressed for optimisation or that have complaints from workers. The parts of the purchasing pipeline that are to be analysed are the

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ABC-analysis of purchased items, confirmations of purchase orders and the supplier relationships between the company and its suppliers. The company wished that with a thorough analysis and rework of these parts of the pipeline, it could have required trust in the process for automated purchases without economic loss and less tedious work tasks. The aim is to map the prerequisites for an automatic purchasing process to provide the company with a basis for building the automation on top of an ERP system. Based on this specific aim, this study has identified two research questions (RQs), which are stated as follows:

RQ 1: What are the prerequisites that must be developed into the case company's purchasing process to allow introducing automatic purchasing methods?

RQ 2: How can new processes be introduced with a theoretical framework to make the existing processes, like the ABC-analysis, better?

This article is organised as follows: [Section 2](#) focuses on the theoretical framework of purchasing, inventory management, modern systems in purchasing and the capabilities in reference required for the case of purchasing development to automation. Study methodology is presented in [Section 3](#), while classifications of purchasing items are stated in [Section 4](#). Automated order processing system is elaborated in [Section 5](#), whereas case company's current situation and ordering process is explained in [Section 6](#). In [Section 7](#), ABC-XYZ analysis at the case company is illustrated. Necessary planning for automated purchasing process is highlighted in [Section 8](#), while various managerial perspectives are demonstrated in [Section 9](#). The study results are analysed and concluded along with future research directions in [Section 10](#).

Theoretical framework

Role of purchasing, e-purchasing, and their objectives

Purchasing is the action of procuring whatever materials the business needs to ensure the flow of production. While mostly this means raw materials, it includes office supplies, machinery, and services. Purchasing is mostly viewed as only the acquisition of goods to the company, but it includes a wide range of different activities that come with the process of fulfilling the needs of the business. The term purchasing is many times interchanged with the term procurement, while procurement is used mostly in a much wider context and purchasing just as the attainment of goods. It is good to go back to the definition of procurement to understand its core function for a business (Waters 2003, 28).

According to Van Weele (2010, 12), the definition of procurement is: 'The management of the company's external resources in such a way that the supply of all goods, services, capabilities and knowledge which are necessary for running, maintaining and managing the company's primary and support activities is secured at the most favourable conditions'. In modern business, purchasing carries an important role in the production workflow since it manages the simple inputs: raw materials. Purchasing is not only about buying items from suppliers, but it also includes using modern tools to ensure the best pricing, optimising order quantities and order time. Over time, more strategic tasks have moved to the purchasing function of organisations, and the function has gained a more developmental and controlling role in the supply chain management process (Essuman, Anin, and Muntaka 2021).

As the role of purchasing and procurement has gotten more complex over time, it has led to a more integrated workflow of supply chain management (Paulraj, Chen, and Flynn 2006; Trent and Monczka 1998). According to Iloranta and Pajunen-Muhonen (2015), the role of purchasing is managing the external resources of the organisation. Purchasing aims to make use of the supplier market in a fashion that the end-customers' needs become fulfilled in a desired way that maximises the company's benefit (Iloranta and Pajunen-Muhonen 2015). This means that the purchasing function must have a broad view of the entire supply chain and its requirements to create purchases that maximise the company's capability to create value to the customer. According to Sakki (2014) it needs to be empathised that while the earlier stands through that supply chain management must be a part of the purchasing skillset, it does not always fit all organisation models and the actions that are done in the order-delivery process can happen in different parts of the company and it involves a lot of different personnel depending on the organisation structure.

Nowadays in addition to traditional purchasing, e-purchasing is becoming attractive to the business community due to its flexibility and reduced lead-time. Belisari, Binci, and Appolloni (2020) created a model to demonstrate how interactions with suppliers and e-procurement help certain forms of sustainable procurement while impeding others. Belisari, Appolloni, and Cerruti (2019) examined how sustainable procurement may have both positive and negative impacts of the adoption of e-procurement and supplier communication in terms of labour, health, and safety, as well as the environment. On the other hand, growing global pressure from stakeholders on climate change and its repercussions for all elements of manufacturing has pushed industry leaders to take on greater environmental responsibilities (Mathiyazhagan et al. (2021). On such perspective, green public procurement can be considered as

a policy tool, which focuses on manufacturing firms to achieve environmental certifications practice, and top management support for availing competitive advantages (Liu et al. 2021; Ma et al. 2021).

Purchasing process model

Modern definitions define purchasing as a strategic function, which has the mission to take care that the organisation has the best external resources in its use. While that is true in the entirety for purchasing, it is separated into three different segments: strategic, tactical and operational. These three parts are all independent but in terms of business they are very dependent on each other. These three parts together form the purchasing process model (Huuhka 2019).

Operative functions of purchasing are the everyday actions in the purchase workflow. Like purchase order sending, order handling, data parameter handling. Operational purchasing has a crucial role in material ordering and saving costs for the business. It basically includes all the functions after a deal has been made with a supplier. Tactical purchasing includes budgeting and contract negotiations. Strategic purchasing is primarily operation development and planning, supplier choice, evaluation and developing the supplier relationship. It must be made clear that definitions and the process model are ambiguous depending on the author or the organisation in question.

In a common term, purchasing is also many times mixed up with *ordering* and *buying*, while they have a critical difference. Buying does not include the determination of specifications, the purchasing function includes communication with the supplier of the material of their goods and specifics in for example environmental impacts and working conditions, this is followed by the contract to purchase from the certain selected supplier. Only after this comes the order process, which refers to the sending of the purchase order for the goods on arranged conditions (Van Weele 2010).

Material planning and inventory management

In purchasing, the fluctuations and the amount of demand are major factors in guiding the purchasing of a certain item. In industrial procurement as in retail, different items or materials have different demands and routes and costs. These all need to be managed in supply chain management to keep the costs low. For this there are methods to time the purchase of each item to a certain point to ensure their inventory costs stay low while they fulfil demand. This is called inventory management, where all the information for ordering products comes from the warehouse and is followed by material planning. It is best used on items that have continuous demand (Sakki 2014).

Material Planning methods differ widely depending on the nature of the finished product and the type of production. There have been done studies widely about the fitting of each method or different types of production, but in the end the method is usually chosen by its easiness for implementation to the workflow (Jonsson Mattsson, 2008).

Safety stocks

In demand-guided manufacturing, safety stocks are always the buffer of items in inventory to uphold a demanded service level and to counter completely running out of material. Safety stocks are a two-sided issue, on the other hand, they keep you some inventory of the item to keep you from running out, but if too much safety stock is held for too long it keeps growing inventory holding costs and ties capital. Safety stock must be set to a certain level so that the item can stand a quick order. This means that the safety stock is tied to the change of demand in an item and must be managed continuously. It also has an impact on the service performance and how fast can an order be answered to. The safety stock also represents the re-order point for an item, since as the inventory closes to reach the safety stock, optimally the new order would arrive at the same time to keep the inventory levels above the buffer. All of it depends on the desired service level of the item (Ruiz-Torres and Mahmoodi 2010).

When estimating the safety stocks, the lead time, and an estimation of the variability of demand should be readily available knowledge. Sakki (2014) proposed a calculation method for safety stocks that includes standard deviation of demand, a reliability multiplier and the lead time as follows:

$$B = ks\sqrt{L} \quad (1)$$

In this function 's' is the standard deviation, 'k' stands for reliability multiplier and 'L' for lead time and 'B' for safety stock. The reliability multiplier is dependent on the desired service level. The reliability multiplier corresponds to the desired service level. Sakki made a point that the standard deviation of the items demand needs to be constantly followed so information systems can update the safety stocks according to changes in demand (Sakki 2014).

Economic order quantity

Economic order quantity is a calculating method to calculate the quantity of an order so that is in line with the consumption demand but also does not raise the inventory amounts too much. It was developed by F.W. Harris in 1915 for stock keepers (Muller 2011). The formula is called the Wilsons formula, and it is used to calculate the minimum point of a quadratic equation (Sakki 2014). The formula stands:

$$EOQ = \sqrt{\frac{2AR}{P^2K}} \quad (2)$$

Where, 'A' stands for the estimated value of annual demand, 'K' is for carrying costs, 'R' for replenishment costs and 'P' for unit price. Carry costs involve all costs related to the handling of the inventory and replenishment costs involved with the costs of placing and handling the order. There are some minute variations of this formula in different materials, but in principle the output is always the same. This formula is used to determine:

- Optimised order quantities
- The timing of the order
- The total cost
- Average inventory levels

The Wilson formula is used to determine a wide array of parameters for ordering a product, but it is only because it works off assumptions for the purchased item. For the EOQ formula to be effective, the demand rate for the item needs to be constant, the carrying costs and ordering costs are completely independent and the lead time is always constant. These are assumptions that do not fit every item purchased so the EOQ is in no means tool for everything (Muller 2011).

Vendor managed inventory

Vendor managed inventory (VMI) is a partnering method for inventory management where the customer and supplier have an inter-company contract for improving supply chain efficiency. With VMI, the supplier makes the decision to make up the replenishment of items and order quantities on behalf of the buying organisation. It is made to reduce inventory costs of the customer, improve service levels and to create business opportunities. The vendor monitors the orders and inventory levels and makes the periodic replenishment, thus reducing the control costs of the re-ordering the product minimal for the customer.

There are prerequisites for VMI to work, it demands a detailed planning and very transparent information exchange between the organisations, which then again raises administrative costs and can raise the costs of the process, or the process of filling orders can turn out to be ineffective. It requires capabilities from the supplier to use the customers' data efficiently to improve inventory levels. In this way, VMI also promotes high-level supplier collaboration to work since ineffective implementation will make it a disadvantage. Niranjana, Wagner, and Nguyen (2012) Because of the risks involved in the trust and transparency of the operations, especially if the item in question is critical to the customers business, the items

chosen for VMI are usually standard items that have steady demand and relatively short lead times.

Kauremaa (2006) considered that the most use for VMI is in supply chains that have bullwhip effect, distortion that travels upstream in the supply chain due to variance in orders. The VMI method reduces the bullwhip effect due to the increase in transparency and shares information of the true demand to the entire supply chain (Kauremaa 2006, 11–14).

Study methodology

Research design

The methodology of this study was adopted as a mixed method where both qualitative and quantitative data were collected and analysed. In the qualitative part of the study, both literature review and a case company were studied. In the case of literature review part of the study, an extensive analysis of the past literature on the topics of purchasing and inventory control and management was studied. In the quantitative part of the study, different calculation methods and tools were used to control the amounts and timing of procuring material of the case company. These tools are analytical methods like the ABC and XYZ-analysis, order point and safety stock calculation. ABC and XYZ-analysis are for prioritising items in the case company's inventory management. Safety stock and order point calculations are for optimising inventory values. In modern production, they are usually included in the calculation methods of information systems.

Study approach

As stated above, this study followed both literature review and case study research approaches. In the literature review part, useful data were gathered from various electronic sources, scientific articles, and publications from the various databases such as EBSCOhost and Science Direct, Web of Science, etc. Other sources of study data are collected from the case company's internal processes such as process flowcharts, internal documentations, databases, etc. In addition, several scheduled face-to-face meetings were organised with the employees from purchasing departments for necessary guidance. Such meetings were added value in decision-making process of the study to correspond with the requirements for the case company's existing processes.

Additionally, data gained from the case company's ERP-system is addressed with statistical methods. By extensively examining the data, it is attempted to notice the aspects relevant to the research subject. According to Kiviniemi in qualitative research, it is ordinary to gather data that is relevant for the study instead of random sampling. Kiviniemi also mentioned

that in qualitative research, the handling of the material is thorough, and the researched effects are aimed to be understood in relation to their context, which is also typical in this study.

Moreover, in this study, the existing ABC-analysis model of the case company is examined in reference to theoretical framework on the subject and then an ABC–XYZ analysis is conducted on the case company's purchased items portfolio to extend their inventory management process to take more variables in consideration. Since the case company already has an existing ABC-analysis model in place, the XYZ analysis is conducted on top of the existing model to understand the purchasing patterns and demand variability. With this analysis, the inventory is regrouped into new item groups. Then from these groups, the items suitable for automatic purchasing are separated (Appendix 1).

Because some items have volatile demand and generally changes happen in demand over time, criteria for items to change groups is also defined. When item changes group, the inventory management methods change so the criteria definition must be robust. The ABC-XYZ analysis provides a basis to determine which items purchasing process can be automated. On top of the ABC-XYZ-analysis, the process for managing the item groups for the automatic purchasing process in the existing and required systems, like the ERP and safety stock calculator and a supplier portal is mapped.

Classifications of purchasing items

Because the purchaser's tasks now involve to inventory management, logistics and a broader understanding of the entire production chain, the purchase function uses different calculation methods and tools to control the amounts and timing of procuring material. These tools are analytical methods, like the ABC and XYZ-analysis, order point and safety stock calculation. ABC/XYZ-analysis are for prioritising items in the inventory. Safety stock and order point calculations are for optimising inventory values. In modern production system, they are usually included in the calculation methods of information systems like, so procurement professionals necessarily do not use these tools as they are, but they are vital parts of the process involving them (Sakki 2014).

ABC analysis for prioritizing purchases

The ABC analysis is a widely used simple method for categorising purchased items by different metrics, usually according to their economic value. The ABC analysis is usually in use even in companies of somewhat moderate sizes since they can have thousands of items in their inventory that require warehouse picking (Ng 2005). It is based on the mathematical Pareto 80/

20 value, which concludes that 80% of all consequences are caused by 20% of reasons and vice versa. When applied to purchasing and material planning, this would mean that 20% of items or suppliers provide 80% of all inventory value (Huuhka, 2022).

The ABC in practice means dividing the items to three or more classes where:

- A-items: very important, expensive and require high control, 0–80% of annual inventory value.
- B-items: medium value, less control and have good metrics, 80–95% annual inventory value
- C-items: least important and require minimal control, 95–100% of annual inventory value (Scholz-Reiter et al. 2012).

The categorisation and the value can differ by the nature of the items, but the most used is their monetary inventory value. The ABC-analysis can be used in varying forms, sometimes it is enlarged to an ABCD-analysis with four categories of items, and this varies by company and the amounts of items and usually how well they naturally fall into categories. According to Sakki the division can be divided into five categories with ABCDE, where the E-class presents the items that have no records of requirements or sales (Sakki 2014). According to Sakki, the basic principle of the ABC analysis, where he defined four classes, instead of three, can be boiled down the following general rules:

- A- and B-classes: Purchase in a steady stream in calculated quantities. With a decent inventory turn, the buyer also has a goal of getting these on for as low price as possible.
- C- and D-classes: Purchased in larger quantities that are still within limits. The control costs need to be lowered and accordingly work efficiency is prioritised.

Guiding operations with ABC classification

While the ABC analysis is a very popular method for classifying items, there are no universal rules for choosing the optimal inventory management methods for each class. Especially guiding the B-class items purchases is difficult due to its 'middle-ground' nature. Buxey (2006) said that the biggest flaw in the literature is in the lack of optimal inventory management recommendations for ABC classes. Usually, the two-bin method is recommended for C-items, but A-items have not decided the best method, even though EOQ is many times mentioned. The B-class is even more difficult. It is understandable that all these methods are situational and depend on the execution of the analysis and the nature of the production (Buxey 2006). The literature is still unanimous on the fact that different ABC classes require different inventory

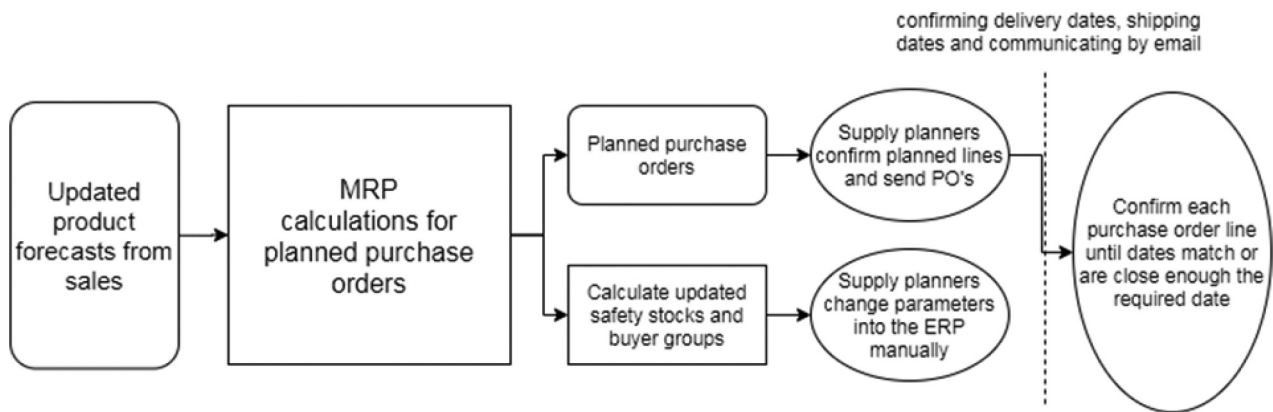


Figure 1. Forecasts to orders flowchart.

methods. The higher the class, the smarter it is to implement more precise control methods compared to cheaper items (Hopp and Spearman 2011).

Aswathappa and Bhat (2009) created a sample for policy guidelines that should be implemented into the material planning organisations with the ABC – analysis. It provides 13 rules for each class to guide the purchasing and sourcing of these items. The table can be examined in Figure 1. It should be noted that these policy rulings are always ambiguous and should be examined and implemented situationally. However, it provides a framework on how to manage each different item class depending on its inventorial value. In their literature, they provided a valid point about the ABC-method. That the distribution of value for inventory stratification is not a system or a technique, it is a fundamental management principle with universal application potential (Aswathappa and Bhat 2009).

XYZ analysis

The ABC analysis is usually criticised for its simplicity and how categorising items only by their inventory value does not provide a realistic image of the nature of the items since there are many more variables that affect the material planning than their value. Therefore, it is usually complemented with the XYZ-analysis that categorises items by their fluctuations and adds three sub-classifications similarly to the ABC classes using the Pareto principle. This is usually done to support the ABC-analysis to provide a broader and more exact image of item values. The classes can be virtually called anything, but X, Y and Z-classes are the most widely used. The three classes are separated as follows (Hoppe, 2006):

- X-class: Only little fluctuation in consumption, stable consumption.
- Y-class: Stronger fluctuations, harder to predict requirements, usually a trend or seasonal consumption item.
- Z-class: Irregular consumption, harder to forecast

The fluctuations of consumption are metered by the coefficient of variation of their consumption values. The coefficient of variation is the ratio of standard deviation for the average consumption over a chosen period (Scholz-Reiter et al. 2012). The way to calculate the coefficient of variation the sample mean, and the standard deviation are required, they are calculated with the following three equations: Average mean:

$$\mu = \frac{\sum X}{n} \quad (3)$$

Standard deviation:

$$\sigma = \sqrt{\frac{\sum (x - \mu)^2}{n - 1}} \quad (4)$$

Coefficient of variation:

$$C_v = \frac{\mu}{\sigma} \quad (5)$$

The standard deviation provides items with certain values ranging '0' to virtually infinity, where '0' means no fluctuations at all the higher the coefficient, the higher the fluctuations for the item consumption. It should be taken to consideration that coefficient is a ratio, so it is affected by the chosen time periods and is not a stable value in that sense (Investopedia, 2020). The chosen period is always a critical factor when conducting the XYZ analysis, since the time need to represent a similar period of for which the items are planned for to be used from the inventory, a year or half a year is considered the general time periods used but there are differences depending on the type of operations. When the evaluations for fluctuation between all consumable items from the inventory are done, similarly to the ABC-analysis the XYZ-classes are separated to their subclassifications by their coefficient of variation (CV). A general classification of XYZ variations is:

- X-items: coefficient of variation < 0.5
- Y-items: coefficient of variation between 0.5 and 1

- Z-items: coefficient of variation > 1. Scholz-Reiter, 2012)

This is a typical classification for the CV of items, but like other parameters in analyses of this type, they vary between organisations depending on their nature and requirements (Hoppe, 2006).

Combined ABC-XYZ analysis

By combining the ABC and XYZ-analysis together, the fluctuations of consumption also are taken to account with the inventory values. The ABC and XYZ-analysis matrix where each of these dimensions complement each other and provide a good view for material planning (Sakki 2009). This is a very standard way of operating. Reese and Geisel (1997) analysed several German companies and found that two out of three companies use the ABC analysis and half of these have expanded it with the XYZ-analysis. Table 1 displays the ABC-XYZ analysis.

It is important to classify these items on a standardised basis along standardised parameters. This is to consider all possible changes in demand and in the fluctuations of demand for items is noticed immediately or at least as quick as tolerably possible. According to Gudehus and Kotzab, the classifications should be repeated monthly, quarterly or at least annually depending on the industry and the nature of production. It was noticed that reclassification half-annually leads to better results than annual revision.

Other classification methods

While the classic ABC-analysis with running totals of currency spent on inventory is probably the most used inventory classification method. Extensions like the XYZ-analysis have been proposed in the decades, which have been studied to include more criteria in the evaluation of different items inventory value. Other

classification methods include the joint-criteria matrix, analytical hierarchy process (AHP) joined with multi-criteria inventory classification and the fuzzy AHP, genetic algorithm for multi-criteria inventory analysis or a weighted linear optimisation model (Kabir and Hasin, 2011).

Current situation and the ordering process at the case company

In this section, the process and the identified issues of the order process at the case company are gone through. Along with it, the ABC-XYZ analysis mentioned in the theory framework is introduced on top of the existing system at the case company, how exceptions are handled, why the case company does wishes for capabilities in automation, and how the need is justified. For the ABC-XYZ analysis, the case company's 6 months production data were used for a handful of selected suppliers that promote a good partnership. All production data were collected from the case company's ERP system and calculated in Excel.

Procurement operations at the case company

The case company is an electronics manufacturer with a large product portfolio of hundreds of products including different configurations of products that are procured to be sold. With all the components and products, the company purchases around 15 000 different items from 400 different suppliers, spanning everything from lasers to gloves. This requires a lot of high-level control from the material planners and sourcing workers to ensure that everything is in place on time. Since the amount of material is so vast, not everything can be bought for inventory to ensure lower amounts of capital tied to the warehouses. Because of the case company procures such great amounts of different items, the company needs to control the costs of procurement and inventory to lower operational costs.

The case company's purchasing team consisted of 11 material planners. The purchase orders come either straight from the MRP system, integrated into the ERP system or as an inventory requirement set from production planners. Materials planners handle sending the order, controlling the dates of arrival that inventory does not over or underflow, communication with the suppliers, verifying the delivery dates into the system and taking care of the master data parameters like order quantities and safety stock levels. All these operations produce data from the ERP system into a Power BI interface that is used to analyse the operational efficiency. This allows to see every supplier's order-to-delivery (OTD) efficiency, amounts of certain items used, purchased and their costs very efficiently.

Table 1. ABC-XYZ analysis classification matrix.

	A	B	C
X	AX	BX	CX
Y	AY	BY	CY
Z	AZ	BZ	CZ

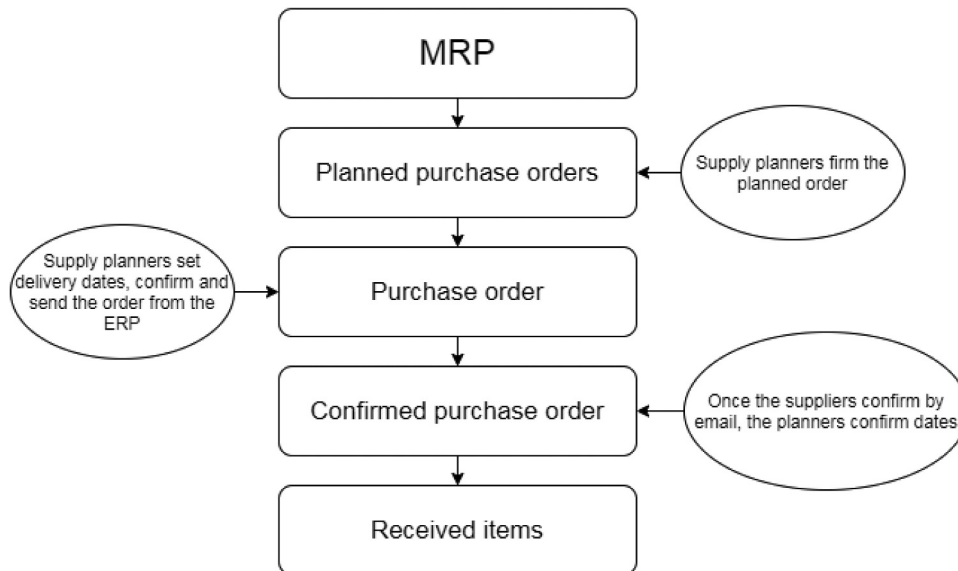


Figure 2. Purchasing process flowchart.

This data is used in this study to calculate the XYZ parameters of each item to conclude the coefficients of variability.

Figure 2 displays the process as seen by the supply planner. From Figure 2, it is seen that most of the actions are done directly into the ERP system, only order confirmations must be externally viewed from emails from the suppliers. The process is centralised into the ERP system, even the purchase order email is generated in the system. The logistics team of the case company does the receiving of the items into inventory. The purchasing team only confirms that the order is ready for receiving. The amount of work required for seeing through the planned order if it completely matches the actual requirements of production varies between products and suppliers. The MRP relies completely on sales data and the purchasing parameters to generate the orders and unless told otherwise or the plans are found to be sub-optimal, the purchasers follow the planned orders provided by the system.

5.2 purchasing parameters and abc-classification

At the case company, inventory and purchasing management has been taken relatively far and there are plenty of control methods and different parameters used in controlling the purchases. There are minimum order quantities for each item that are set either by the purchasing team or by the supplier to limit the purchased quantities to economic amounts. Order quantities are not calculated by Wilson's formula. Safety stocks for each item are updated by planners each month after the forecasts is updated for finished products. The safety stocks are reported from an Excel report that calculates the quantity of 4 weeks of demand for each item from the average consumption per year. That averaged 4 weeks of consumption forecasts represents the safety stock for every item. There

are also items that are not forecasted due to their nature in production, and they do not have calculated safety stocks.

The case company already has an ABC-analysis and uses it during its purchasing process. It very much uses the ABC-analysis as proposed by Sakki (2009) that has four classes from A to D instead of the traditional ABC. In addition, just like in Sakkis' model it has classifications for exceptions. These exceptions are:

- X – An item that has an issue or an exception and has separate order methods provided by a sourcing manager
- H – An item that is considered as an abandoned item in production or non-production.
- E – A non-forecasted item that is purchased only when required.

The case company made its separations for the item classification as follows:

- A-class represents 5% of items with highest inventory values of forecasted purchased items
- B-class represents 15% of items
- C-class 30%
- D-class 50%

For a management purpose, these classes are telling of the item's coverage group and order sizes. Each class has a time frame for orders to ensure that higher value items have shorter inventory turns to decrease inventory stock. A-items are ordered weeks' worth of value, B-items 2 weeks, C-items one month's consumption, and D-items are ordered 3 months of consumption. The item classes represented as each item's 'buyer group' that is an abbreviation that tells which are the

items sourcing manager, supply planner and the ABC-class. There is also an added '+' to indicate if the item is a buffered item, and that means the safety stock is half of actual since the supplier holds a safety stock for the case company in an VMI type fashion.

The idea with implementing this ABC-classification was not only to guide the inventory management of these items, but also aid purchasing in managing the workload for items so it would be quick to see which items require a more sensitive care due to their inventory costs. The E-class is the largest class with thousands of items in it, but it is not relevant when considering the control of items since these items are not forecasted at all for production, so they remain outside of consideration in this work. In this project, the work is for the forecasted items only that are more easily managed.

The buyer groups and ABC-classes are also updated monthly through an Excel-report that calculates from the forecasts the newly reported forecasted inventory costs and proposes new classifications for items, which are then updated with an integration to the case company's ERP systems directly with the safety stocks. The Excel report demands data to be exported from several separate Excel-files and PowerBI web application to make sure that all parameters are correct for the supply planners to use in their work. The report requires forecasted consumption, safety stocks, on-hand inventory, warehouse locations and minimum order quantities for each item. The system does have an RPA (Robotic Process Automation) system designed to import the parameters automatically to the ERP, but this has also still led to many false positives and requirements for manual adjustments.

Figure 1 displays the various processes involved in forecasting an order. Here, the step described within a circle indicates an action by the purchaser and the step within a rectangle represents a system action. In this process, the supply planners see a list of purchases in lines that include amounts, the vendor and the calculated order date to match a set lead-time for that item in the item's parameters. From that list, they gather a list of whatever is required at the time by the period of the ordering date. For some suppliers, a weeks' worth of orders is gathered at once for an order once a week, these are suppliers that have hundreds of items and orders are set every week. Other suppliers have smaller orders that are set whenever their lines appear in the planned order list in the ERP. The orders are sent automatically through the ERP by email in pdf-format as an attachment when the purchaser confirms the order after checking all the lines calculated dates.

For weekly orders, this basically means setting all the lines to next week's delivery date and confirming the order. The order is confirmed through an email response by the supplier that mostly includes an

attachment file in whatever format they use. Some suppliers can confirm just with a simple text response. The planners go through these emails and confirm whatever date the supplier responded with as the 'confirmed delivery date' line by line.

Aim and desire for final process

Using this information about the current processes and their difficulties, a sketch of the final process and the changes it could bring to the current system can be formed. Going through the wishes for development, the potential uses of the ABC-XYZ analysis boiled down to the following:

- Provide sourcing managers with a managerial tool to gain information of their item portfolio in purchasing.
- Provide supply planners with a quick view to manage the care certain items might need in purchasing and control purchasing parameters accordingly.
- With a fast view into demand variability in items, control costs should be guided to more difficult items and lowered from ones with stable control
- Provide items for listing that can be included in an automated purchasing process to lower said control costs.

After the categorising of the items has been done a basis for an automated process workflow has been provided. The aim for the automated process is to guide the expertise and resources of the purchasing team to cases that require more management and control and thus leaving mundane and 'easy' purchase orders to an automated system. This should eventually lead to lowering the number of resources required in a procurement team, lowering costs, and creating a more interesting working space for the team right now. With an automated system taking care of low volatility items and the purchasing team being available for more control over high value items, there should be more resources to optimise inventory parameters to ensure lower tied capital in the inventory. This again lowers operational costs and promotes a more lean and lossless process.

ABC – XYZ analysis at the case company

In this section, for the requirements of the case study, the ABC- and XYZ analyses are taken into practice. In the analysis phase, the process of categorising the items is done first. In the next phase, the ABC and XYZ analyses are combined to see what kind of quantities each class represents. In the combination phase, six months production data is used. This data is extracted directly from the case company's database

using the Microsoft PowerBI reporting tools that is used to gather data from the ERP system and the analysis is done in Excel. The ABC-XYZ analysis is planned to be extended to be used for all items in the purchasing portfolio but for chosen key suppliers it is used as a tool to take automated purchasing pipeline to development.

The process of classifying items

By classifying the items, it can be determined how each item will be handled and how they behave in the item in terms of their demands. Finally, different handling methods and material planning methods can be assigned to each class. In this case, especially if there is an interest in the possibilities of automation, stricter management and more effective safety stock calculation is necessary. Duchessi, Tayi, and Levy (1988) defined four different stages for the item classification:

- Define proper classification criteria
- Define the control needs for different classes
- Pick the proper material handling method
- Implement

For this, understanding of the nature of the items and criticality for the company must be understood. After classifying the control requirements must be defined for each class. Do all classes require the same strictness in the control and what are the optimal inventory levels? After this the methods and processes can be implemented properly (Duchessi, Tayi, and Levy 1988).

Table 2. Expanded ABCD123 – classification table.

A1	B1	C1	D1
A2	B2	C2	D2
A3	B3	C3	D3

Expanding to the XYZ analysis

The suppliers and the items are chosen and mapped to expand the ABC-analysis into an ABC-XYZ classification. As there are already items of X-class, it was chosen to change the expanded classes to 1, 2 and 3. This is done to avoid the confusion and it helps quick identification. Numbers were chosen to provide an intuitive idea of variation of demand. The classes that come from this calculation are depicted in Table 2. The expected final product of this analysis is to provide a similar table that includes handling methods, rules and restrictions of each item class for planners and managers to help manage their supplier's items and decision-making in how procurement could be developed. Also, these tables and calculations are to be used continuously when the classifications should be changed. These classifications will be integrated to the ERP system to imply to suppliers quickly how are they to be managed when managing parameters and allocating time into controlling purchases. It should help purchasers control their amount of work. Finally, it serves as a tool for developing an automated purchase order process to identify the items that could be moved to that category.

Calculating XYZ classifications

The renamed ABCD123-classification was done in Excel using external data connections to the case company's SQL-database. The SQL database has stored in it all purchasing and inventory-related data, like amounts of purchase orders, confirmation dates, inventory levels and consumption. The data was formed into a pivot table (Table 3) with the chosen suppliers' items filtered to a list. The columns of this pivot-table are every month's consumption for production or sales with total sum of the year's consumption. For this analysis, the consumption of August 2019 – July 2020 was used.

The choice of the time frames also carries a role in the XYZ-analysis because it is vital to understand that changing the time frames also affects the final

Table 3. Snapshot of the ABC123-calculation table.

May 2020	June 2020	July 2020	Grand Total	Average Mean	Std Dev	Coefficient of variation	XYZ-class	ABC 123
92	20		1593	145	170	1,17	3	D 3
1344	1834	4020	32084	2674	1726	0,65	2	D 2
2292	1852	1416	26598	2217	862	0,39	1	D 1
		120	392	78	44	0,56	2	D 2
758	740	732	16375	1365	483	0,35	1	D 1
1062	905	474	12344	1029	431	0,42	1	C 1
16	12		248	25	24	0,95	2	D 2
390	582	66	4902	409	269	0,66	2	D 2
44	36		514	47	23	0,49	1	D 1
88	76		1016	92	41	0,45	1	D 1
1938	1196	444	16106	1342	430	0,32	1	C 1
1734	3548	936	36396	3033	1686	0,56	2	D 2
	30		90	45	15	0,33	1	D 1
5050	4231	202	151516	12626	12230	0,97	2	C 2
	5		64	11	8	0,73	2	D 2

values, the longer the time frame the more even the variations will turn out, meaning the coefficient of variation decreases (Hoppe, 2006). Like the initial ABC separation analysis, all items that have an ABCD-classification of E, H or X were filtered out. According to Hoppe (2008), the variation of demand is an apt criterion for the XYZ-analysis when the goal is improving service levels or optimising inventory values.

Transferring items to new class

With time and changes in requirements of produced items, or more efficient purchasing operations, the nature of the items' demand can change. This means for this analysis that it should be transferred to a new item classification and the analysis must be done again. The continuous updating and following an items activity and changing the purchasing parameters continuously is very difficult. The analysis should be conducted periodically, like mentioned in the theory framework, it was researched that bi-annual analysis of the item groups is many times the most efficient manner.

In the case of the company, bi-annual seems like a reasonable time frame for these analyses. Since the case company sends forecasts of the MRP's planned purchases for their suppliers and the order quantities are dependent of the item class a purchased item is sent, the classification cannot be changed continuously since this would make it difficult for the suppliers to prepare stock for the case company to purchase. In practice, the time frame could be anything from monthly to annually. It is important to get the analysis to be understood in the organisation and to get purchasing and sourcing staff to understand the underlying logic behind this analysis before the timeframe should or could be shortened. The shortened time between changes in class would also mean more precise tracking of demand volatility. Updating to the classes would be easy as the case company has, and interface made for Excel files that can update certain parameters in mass. The updated classes need to be copied as rows from the XYZ-analysis table to the update file and imported and all classes change. It is quite easy at this point since the item classes are together with the buyer groups as purchase parameters in the ERP.

Planning automation in the purchasing process

In this study, the necessary planning for the automated purchasing process is mapped and a system recommendation is presented. These are mostly based on

empirical observations of the case organisation, processes, and documented restrictions. The theoretical side of moving into automated purchase orders comes from Rantala's (2016) works, since he has many extensive studies on purchase order automation in a Finnish industrial frame of reference.

Parameters and set up for automation

As mentioned earlier, automated purchasing order requires three core things: a supplier relationship, item classification and system capability. Item classification comes with the idea that the data behind the purchased items is understood, and the parameters are stable and manageable. Purchase parameters such as Minimum-order-quantities (MOQ), safety stocks and lead times are vital to be understood and settled by each party. In the case company, an Excel-based calculator is used to forecast the production needs of every item. This includes every item that has ABCD-classification. This calculator is set up with 12-month forecasts for each item needs in production and calculates the average of 1 month's requirements to be the safety stock, 2 weeks if there is a VMI buffer stock settled for the item. MOQs and lead times come from the supplier and are negotiated between the sourcing managers who own the supplier relationship.

Mapping the automated process

The most important part in automating the process for the case company was to understand the operational purchasing team's way of working and automating the parts that need automating. The two main parts of automating an order are to create the order by matching the parameters set and the confirmation of the delivery dates from the supplier. The first part of the process is relatively easy. Since through the item classification and an established vendor relationship, the items that are ensured to arrive as promised are known. The purchasing parameters handle the rest. Since, the MRP creates the planned orders and counts their lead times for the right delivery dates and proposes the orders at that date automatically, it would be the new automations job to only set the right dated purchases together and confirm them into a prepared purchase order. At this point, the process is still wanted to be held in human hands before the automation could be given the entire purchase workflow.

The confirming of the dates into the ERP automatically is a more complex process to automate and requires some amount of interfacing with other systems since suppliers have their own methods of confirming purchase orders. This makes automation difficult since the source material for the dates is not the same each time for a machine to read and transfer to the system. This separates the possibility

for a system into two directions: either automate the reading and transferring of the data by a system or create a pipeline where all the confirmation dates come in uniform ways. The proposal for a process most fitting for the case company's needs that also promotes supplier relationship development and provides a new interface for working would be a system, where the suppliers can insert the dates themselves to the orders directly and they would be copied as confirmed to the order in the ERP system. The proposed automation process is depicted in Figure 3.

From Figure 3, it is noticed that workflow for an automated purchase ordering consists of three parts namely item classification, system capability and supplier collaboration. Item classification represented as the three first actions. Using external tools from the main system (the ERP), the parameters are calculated or imported according to sourcing agreements or case company's policies. These parameters are the solid base that is needed for enabling the process. System capability takes up the rest of the process; it includes ERP, capability

to material resource planning inside the system and the external system, where purchase orders are confirmed. Supplier collaboration is the most bottom part of the process, where setting up the confirmation process requires communication and shared systems with the supplier.

System recommendation

From Figure 3, it is seen that there is a part that case company does not own now and that is the external system that would allow suppliers to confirm the purchase orders. To reach the wanted process, flow into a system that allows suppliers to confirm orders without sending an external message like a purchase order confirmation email. This is not new technology and there are several established systems that are developed for the purchasing process. A common solution is the EDI (electronic data interface) document confirmation and another, more modern system is a supplier portal system.

After reviewing the EDI process and its requirements in terms of case company's capabilities and

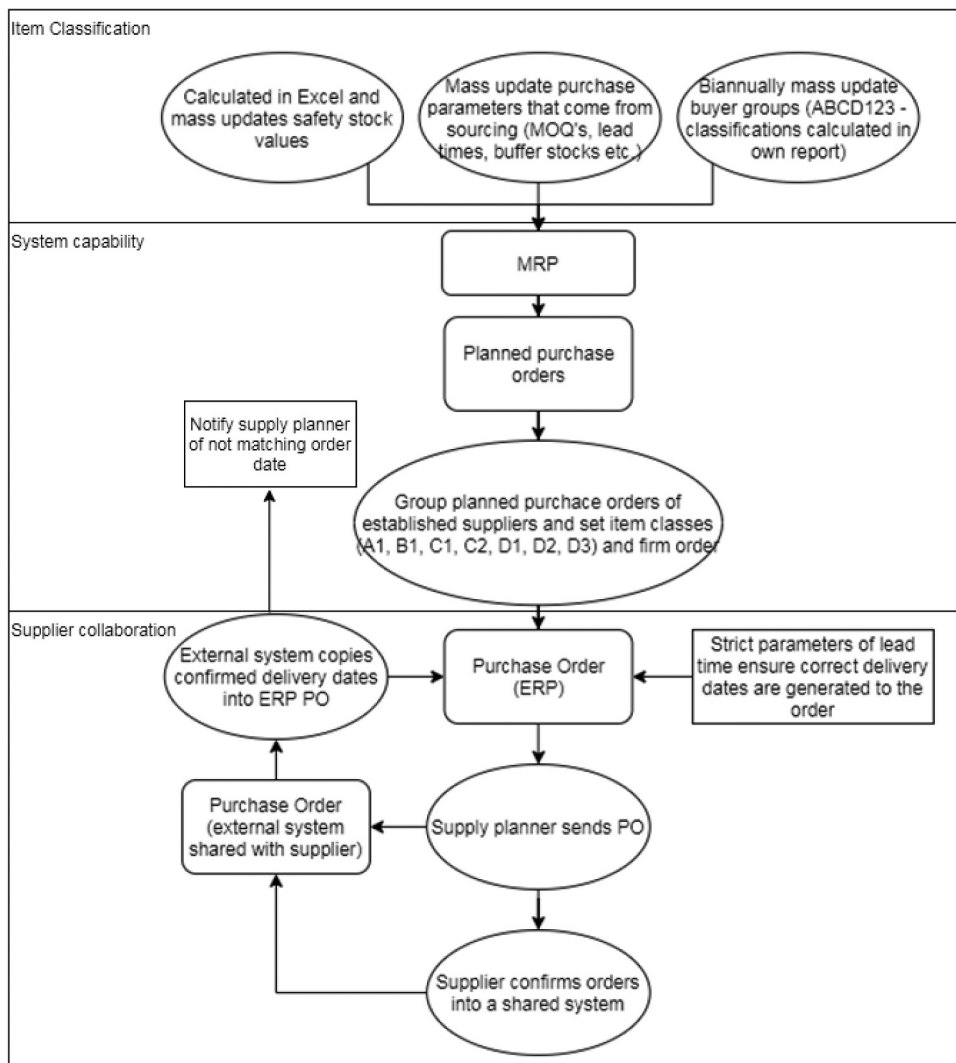


Figure 3. Workflow for automated purchase ordering.

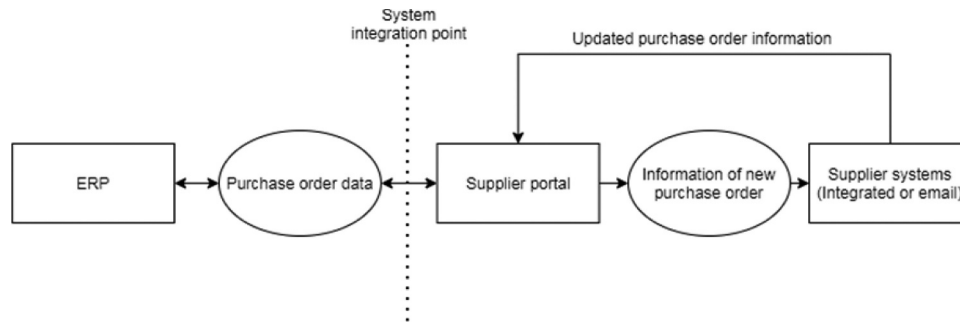


Figure 4. Supplier portal purchase order workflow.

resources specialising the automated process with the suppliers. The EDI process requires work from both the supplier and the case company. While this does require the supplier collaboration ideas represented in this study. The case company does not want to put risk into putting pressure to suppliers to change their processes too much or require infrastructure changes. Because many of the supplier companies are bigger companies and the case company is not always a key client for these larger distributors and manufacturers so to commit to building automation a solution is wanted that can be expanded safely for a larger group of suppliers not dependent on the size or the intercompany relationships. It was felt that the EDI process is not the most dynamic or feasible at this moment.

Supplier portal

A supplier portal gives the capability to the suppliers insert data into the organisations system. This supplier portal comes with the issue of getting suppliers on board using a new system, where supplier collaboration comes in. This requires transparent communication with the suppliers to build a more efficient purchase order. Another issue that surrounds a supplier portal is the return on investment, since the savings created by a system like this are mostly indirect and developing new integrated systems are costly. The returns come from at first glance small things like lowering email traffic, taking away the confirmation time from purchase order processes and focusing on exception cases and elevated confirmation data quality.

Direct savings come from more focused supply planner work time and raised quality, which should lead to less required resources into procurement and purchasing in the long haul. These difficulty returns to argue for management are responsible for allocating costs into developing new systems and processes. In the case of a company, where there are 11 supply planners doing purchasing operations, even a few per cent taken away from the workload provides quantified savings. The average number of

purchase orders sent daily is 11; these orders can contain dozens of items purchased. Getting an automated workflow for 'easy' orders that contain fixed order dates and delivery dates without having to worry about the confirming would free up hours of workload to develop and manage more difficult and time-consuming cases.

Creating and confirming purchase order dates and deliveries is estimated to take sometimes even 50% of a purchaser working time. This 50% includes the difficult cases too, but if an automated workflow could reduce this amount by 20%, would already mean a weekly saving of 44 h between the purchasing team. That already counts for thousands of dollars monthly and the proposed raise in quality and throughput time increase that earned rate with reducing fixing work and making all work faster. This requires commitment from management, operational work force and the supplier to build and believe in the efficiency of automated workflows. The process flow-chart for the supplier portals confirmation process is pictured in Figure 4.

Conclusions, limitations, and future works

This study was done as a part of a project at the case company to create ways for enhancing the purchase order process and remove more tedious parts of operational purchasing workforces' day-to-day operations. The goal of this study was to present the requirements for the case company's current way of working to gain a step forward to automating their processes and developing a more efficient procurement workflow. The first research question was of finding the prerequisites for the current system to move into automation. The second question was how current analysis methods, like the ABC-analysis, could be expanded to a more usable form. The second research question handled the entire inventory management processes of the case company and for the first question, a selected group of suppliers was chosen for studying possibilities of upgraded methods.

Study contributions

In the theory framework, the focus was mainly on how procurement and inventory management are done and how does literature cover item classification methods, like the ABC and XYZ-analysis and their possibilities. In addition, automated processes and its requirements are covered in the final part of the theory framework. For the empirical study part of the study, it was concluded that an expanded ABC-XYZ analysis for the chosen set of suppliers purchased items should be done to figure out the demand nature of items. Since the goal of the study was to find out of the case company's current systems would gain a more usable form, a 9-part matrix of different classification groups that include very practical ideas of the items should be handled in terms of how difficult or volatile they are in terms of demand fluctuation. The demand data used in the analysis were for each item monthly demand in production or sales from 12 months. This matrix would not also provide the limitations and guidance for each item group but create a need for managing the items purchasing parameters to allow even for providing automation.

From the analysis, it was visible that for these six suppliers handled in the analysis, most of the items supplied belong into the C1, C2, D1 and D2 categories (67%). These are the item classes with the low volatilities in their demand patterns and lower inventory values and thus lower strategical value. This was very fitting for the aims of this study, since these are the items that are generally deemed to be possible to be viable for automating since their demand is predictable. When this information is combined with supplier collaboration to ensure a high level of information about purchase parameters like lead times from the supplier, it is deemed possible that an automated purchasing pipeline can be set up for these items. For the more volatile and difficult items, more optimised order planning methods like optimal safety stocks and only manual ordering with is taken to use to avoid stock outs. Quarterly performance checks are necessary for items in high values, high volatility classes.

In the second part of the empirical study, the requirements of an automated, or even a semi-automated, purchase process workflow are mapped. Here, the current processes parts deemed too tedious or time consuming and turned into a sketch of an automated process. A management decision dictated that the process should probably start with the idea that the entire purchase process is not handed to automation and the first phase should include checks by a human for insurance to this is also taken into consideration.

To conclude, the extended ABC-XYZ analysis provides a strategic map for not only operational purchasing, but also sourcing to map each supplier's item

portfolios demand volatility and this data can be used in many ways to enhance decision-making. The analysis should be repeated bi-annually. The analysis also provides a basis for finding items that should be considered to not require attention by purchasing staff, since they are continuously ordered. The case company still has some steps in building required system capability to ensure a completely automated purchase process, but this thesis's findings should provide a proper starting point and a roadmap for understanding the requirements of such a concept.

Managerial implications

The implication and aim of this ABCD123-item classification system is to help managers to understand the volatility of different items and specify critical items so that they can have precise discussions with their suppliers. The item classification matrix works as a roadmap for sourcing the managers, where they can make more justifiable decisions on how to set safety stocks and lead times, for example for critical items. It also helps divert and manage resources on what categories and sets of items they should focus their work on. It brings information about the procurement portfolio and helps to understand the place of each item in the importance hierarchy. The biannual set interval for re-analysing the classification also creates rhythm into the operations and somewhat makes sure that there is precise information continuously.

Another use of the item classification for the managers is the ability to use it in supplier collaboration development. With the matrix and the knowledge of coefficient of variation factors, the discussion about automating ordering with suppliers can be started. Sourcing managers and purchasing staff have meetings with suppliers every quarter about procurement, transport and supply performance. Now there is more precise information on the critical sourced items and guidelines on how they should be set with parameters to have proper inventory. This requires communication with suppliers, but the item classification will help with that.

The item classification system is also a development tool in understanding the specifications of each items demand profile. This helps the operations managerial team in developing systems, like an automated purchase process, to help the operations in developing to a more optimised. To concise, the item classification is for economical item management, optimising supply and decision-making in procurement management.

Study limitations and future research directions

This study contains several limitations which are worthwhile to mention. First, the study focused on

a specific case company and analysis of its purchasing department, which limits the study to a wider spectrum. Second, the study analysis conducted limited literature in the field of purchasing and inventory management, which can be extended to more advanced systematic literature to obtain deeper knowledge and understanding. Third, only ABC and XYZ analysis methods are employed to classify the purchasing items rather using other available tools and methods such as fuzzy logic-based multicriteria, decision-making process, machine-learning for multicriteria inventory classification, vital, essential, and desirable (VED) classification method, slow-moving and non-moving (FSN), scarce, difficult and easily (SDE), etc.

For future studies, the implementation and choosing of a correct system supplier for building a completely automated purchasing workflow should be looked at. The process workflow of this thesis represents a first step of automation in purchasing that still includes semi-automatic steps. Next cases could also include such topics as implementing machine learning tools to read purchase invoices and other documents to help ease document handling and confirmation work.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Appendix 1

Matrix of item class control policies for the case company.

	A	B	C	D
1	<ul style="list-style-type: none"> Optimized safety stocks Periodic checks of performance Option for automatization JIT supply chain for optimized value, low safety stocks 	<ul style="list-style-type: none"> Automated purchase orders with manual interception JIT supply chain methods Fixed order periods for perpetual inventory 	<ul style="list-style-type: none"> Automated purchase orders and confirmations Fixed order periods for perpetual inventory 	<ul style="list-style-type: none"> Automated purchase orders and confirmations Lower control resources Fixed order periods for perpetual inventory
2	<ul style="list-style-type: none"> Periodic checks of performance JIT supply chain for optimized value Manual control 	<ul style="list-style-type: none"> Basic purchasing procedures Medium control resources Manually adjust parameters 	<ul style="list-style-type: none"> Automated purchase orders and confirmations Purchase parameters ensure lead times and dates High safety stocks and order quantities for lower control 	<ul style="list-style-type: none"> Automated purchase orders and confirmations Purchase parameters ensure lead times and dates High safety stocks and order quantities for lower control
3	<ul style="list-style-type: none"> High control of PO confirmations and lead times Periodic checks of performance High communication with supplier Priority in rationalizing supply 	<ul style="list-style-type: none"> High control of PO confirmations and lead times Priority in rationalizing supply 	<ul style="list-style-type: none"> High safety stocks and order quantities for lower control Aim to understand supply dates for automatization possibility 	<ul style="list-style-type: none"> High safety stocks and order quantities for lower control Aim to understand supply dates for automatization possibility

Figure 1