Implementation of Industrie 4.0 in Purchasing: A Case Study

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ABSTRACT

In production and manufacturing Industrie 4.0 is increasingly known and more literature is published continuously. It is recognized that there is still a lack of attention to other activities of a company such as purchasing, while at the same time integration is highlighted as a main concern for implementation. To improve knowledge about the actual usage this research is directed at purchasing in Industrie 4.0. A case study at Scania, a multinational truck and bus fabricator was conducted to analyze the practical progress of purchasing. The qualitative data was collected from a purchasing manager and employees of the digital factory department, exploring Scania's options for Industrie 4.0. and was then analyzed based upon a maturity model and linked to each other. It showed that while there is a clear plan of implementation for Industrie 4.0 features in manufacturing it was recognized that there is a lack of knowledge within the purchasing department and any application of Industrie 4.0 features is still at a pre-mature stage. There is a new purchasing strategy that, if fulfilled, contributes to the first stage of the smart factory vision, that is having standardized processes on a global level. However, there are no following steps planned for the purchasing department itself. On the other hand, it is visible that even without a direct application of Industrie 4.0 processes throughout the purchasing activities it still affects the purchasing department . Especially because with the application the processes are analyzed better and characteristics of a desired product can be more detailed and specific. It will be possible to improve testing of products and prediction of failures sequentially, reducing the number of errors when placing an order. For the future, more research about the interaction should be done. This will contribute to the knowledge of Industrie 4.0 throughout disciplines. Collecting more data will also help verifying the results, which was not possible in the time limit of this thesis.

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Keywords

Industrie 4.0, Purchasing, Implementation, Maturity model, Case study

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1. INTRODUCTION

It is striking to see what technological developments took place in the last decades. This is also visible at production sites, because so called revolutions took place. By now three of such industrial revolutions appeared and made the usability of products as we know possible. With a report by Kagerman, Wahlster and Helbig in 2013 the concept of Industrie 4.0 was explained for the first time. This is considered the fourth industrial revolution that is currently evolving. Since this first introduction, a lot of literature has discussed the concept, and a lot of researchers put effort into trying to understand and explain it. Different aspects of Industrie 4.0 are important. One of these is integration, which includes the internal and external environment of a company.

Still, the practical implementation of Industrie 4.0 is only roughly discussed and it is unclear what progress has been accomplished in companies. Focusing on purchasing in specific, there is barely anything written in literature. To counteract this lack of information, a case study will be performed in this research paper. The purpose of this research is to gain new insights and understand the implementation process better, by means of one big, multinational production company. This research will be beneficial for understanding the implementation process, but also for the company itself to see where potential lies and what steps should be taken next.

This thesis will be structured, starting with a clear and thorough literature review in Section 2 and recapitulation of the concepts that will be used. Section 3 will mention, the research question, including sub questions that came up during the literature review in order to have a clear goal of the research. The data gathering method and all other research connected topics will be discussed in the methodology chapter, in section 4. To get an understanding of the case, in section 5 the company at hand will be introduced and relevant facts will be mentioned. Followed by the findings in section 6 that came up during the data collection. From these findings it will be possible to recognize a conclusion and answer the earlier mentioned research questions (section 7). In the end (section 8) the discussion will mention limitations and future possibilities this research contains.

2. LITERATURE REVIEW

2.1 Past

The term Industrie 4.0 was first mentioned in 2011 by the Industrie 4.0 working group, an initiative by the German government to support the development in industry. It is commonly seen as the fourth industrial revolution. A revolution is a number of changes that, taken together, constitute a development (Deane , 1979, p. 1). This new stage could only evolve because of developments that preceded it, starting with the first industrial revolution. It occurred first in Great Britain, in the second half of the eighteenth century (Deane , 1979, p. 2). This included the introduction of new energy sources (Jensen, 1993, p. 834), such as steam and waterpower to the distribution and manufacturing process (Bauernhansl, Hompel , & Vogel-Heuser, 2014, p. 5). It triggered a rapid growth of productivity and living standards (Jensen, 1993, p. 834). The second industrial revolution introduced electrically-powered mass production based on the division of labor and took place in the beginning of the 20th century (Kagerman, Wahlster , & Helbig, 2013, p. 14). This caused further increase of productivity and the decrease of production costs and prices (Jensen, 1993, p. 834). The third industrial revolution started only in the 1970s. It was caused by multiple developments that included physical and management technology, global competition, regulation and taxes (Jensen, 1993, p. 835). It did not only increase the automation of the manufacturing process but, with electronics and information systems, also took over a proportion of thinking (Kagerman, Wahlster , & Helbig, 2013, p. 14). There are multiple causes that can trigger such revolutions. An important one is technological advancements (Tomory, 2016, p. 152), new innovations and their application in manufacturing made such revolutions possible. Another one is the continuous population growth (Lucas, 2004, p. 2), as more people require more products. Keeping up with the growing demand, it is necessary to make production more efficient and cheaper.

2.2 Present

Requirements and expectations about products are increasing. A study by the Fraunhofer institute (2013) identified some themes directed at the future of products and production. These are dealing with complexity, capacity for innovation and flexibility (Spath, et al., 2013, p. 43). This calls for further developments and can be identified as a cause for the fourth industrial revolution (Industrie 4.0/Industry 4.0). Another cause for developments is the need for more efficiency. Ramsauer (2013, p. 9) defined four resources within production that are object to continuous improvement of efficiency. These are energy, material, human and financial resources. To optimize or reduce the usage of these, companies must improve operations.

For the past decades increasing use of information and communications technology (ICT) was applied to production processes and by now computers or other technological devices are getting smarter (Kagerman, Wahlster , & Helbig, 2013, p. 13). Applying such developments and new technologies allow new ways of production to emerge. Soon it will be possible to connect all parts of a value chain in a network, called the internet of things and services (Kagerman, Wahlster , & Helbig, 2013, p. 13). These technologies are expected to cause disruptive changes to a lot of business activities (Strandhagen, Alfnes, Strandhagen, & Vallandingham, 2017, p. 344). Summarized, the amount of changes can be identified as a revolution (Deane , 1979, p. 2).

For Industrie 4.0 it is still rather hard to find one accepted definition. There is a lot of literature and while mostly the characteristics are similar or the same, it is still a vague term. The working group that established the concept of Industrie 4.0 wrote a final report in 2013 where it is stated that it is based on Cyber-Physical Systems (CPS), as this

translates networked plans into actions. These systems are integrations of computation with physical processes (Lee E. A., 2008, p. 1), and comprise smart components of the supply chain that have been developed digitally and feature end-to-end ICT-based integration (Kagerman, Wahlster , & Helbig, 2013, p. 14). Such systems support the development of smart manufacturing as networking and communication belong to its main features (Wang, Torngren, & Onori, 2015, p. 16).

Those new manufacturing applications propose the utilization of predictive manufacturing, which needs prediction tools in order to systematically process information (Lee, Bagheri, & Kao, 2015, p. 21). Moraes and Lepikson (2017, p. 730) propose that the transformation of industry is fueled by different technological advancements, that are based on Internet of Things (IoT), Cyber Physical Systems, Big Data, Cloud Computing, Collaboration Systems and Intelligent Robots. Another way to connect and communicate, especially in the global context is using a Global Virtual Model, with which visualization (virtual reality) and monitoring at multiple locations can be shared better (Kovar, Mouralova, & Ksica, 2016, p. 3).

Industrie 4.0 and its technological features bring multiple benefits within the manufacturing process. This includes machine health predictions, reducing labor costs and energy-savings by optimized scheduling (Lee, Bagheri, & Kao, 2015, p. 22). Additionally Industrie 4.0 contains multiple features that benefit stakeholders: the meeting of individual customer requirements provides a new level of flexibility on different aspects of business processes, optimized decision-taking through full transparency in real time, resource productivity and efficiency, creating value opportunities through new services, being able to respond to demographic change in the workplace, a new work-life balance and a high-wage economy that is still competitive (Kagerman, Wahlster , & Helbig, 2013, p. 16). Next to that, Industrie 4.0 will allow to react to challenges such as resource and energy efficiency and urban production (Moraes & Lepikson, 2017, p. 734).

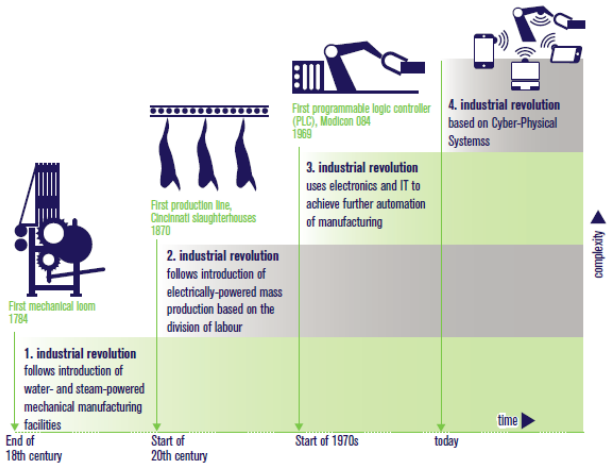

Figure 1.: From recommendations for implementing the strategic initiative INDUSTRIE 4.0, Kagerman, Wahlster, Helbig (2013, p. 13), originally from DKFI (2011)

Figure 1 positions the four revolutions not only on a time dimension but additionally on the dimension of complexity. Thus, the newest features are more complex, increasing the complexity of the whole production process (Hermann, Pentek, & Otto, 2016) and that does affect their application in companies. This results mainly from the increased need for adaptability of systems, and companies need to find appropriate tradeoffs for the design of processes (Wang, Torngren, & Onori, 2015, p. 6). The usage of Industrie 4.0 mechanisms needs integration along different aspects. First, integration across all participants along the value chain (horizontal level) and across all layers of automation (vertical level) (Schumacher, Erol, & Sihn, 2016, p. 161) and thirdly the integration of data across functions (end-to-end digital integration), which requires fundamentally reshaping the organization (Geissbauer, Weissbarth, & Wetzstein, 2016, p. 9). This complicates the application of Industrie 4.0 and companies might struggle with applying new systems to all departments, which is crucial for gaining or maintaining a competitive advantage (Luzzini & Ronchi, 2011, p. 24).

2.3 Industrie 4.0

Since the term Industrie 4.0 was first mentioned in 2011 (Torn, Pulles, & Schiele, 2018, p. 1), a lot of papers mentioned different but similar definitions. Lasi et al. (2014) described it as “On the basis of an advanced digitalization within factories, the combination of Internet technologies and future-oriented technologies in the field of ‘smart’ objects (machines and products) seems to result in a new fundamental paradigm shift in industrial production. The vision of future production contains modular and efficient manufacturing systems and characterizes scenarios in which products control their own manufacturing process.” (Lasi et al., 2014, p. 239). This is quite broad and does not mention the technical aspects sufficiently. Wang et al. (2016) defines industry 4.0 as “a CPS oriented production system that integrates production facilities, warehousing systems, logistics, and even social requirements to establish the global value creation networks” (Wang et al., 2016, p. 159) This is more based on technical developments and names a lot of components.

These are just some examples of definitions, but to have a way of clearly recognizing Industrie 4.0 processes Torn, Pulles and Schiele (2018) defined certain characteristics that will be applied in this thesis. These are:

1. Cyber-physical systems, the “transformative technologies for managing interconnected systems between its physical assets and computation capabilities” (Lee, Bagheri, & Kao, 2015, p. 18).
2. Autonomous self-organizing system, that are able to react to novel situations and do not have an inflexible pre-defined path.
3. Machine-to-machine communication, which implies that there is no more human interface in a process, but machines communicate directly

with each other (Torn, Pulles, & Schiele, 2018, p. 5).

These three characteristics combined give a basis on which Industrie 4.0 processes can be recognized.

2.4 Purchasing

Purchasing is both, a functional department and a functional activity in a company (Monczka et al., 2009, p. 8).

Torn, Pulles and Schiele (2018, p. 5) defined regular purchasing activities along the purchasing year cycle, which includes 6 steps. Purchasing plans the demand (1), categorizes the strategy (2), selects the suppliers (3) and contracts the chosen suppliers (4). These steps can be summarized as strategic sourcing. Continuing, the plans are executed (5) and evaluated (6). A visualization of the year cycle can be found in the Appendix.

By performing activities in an organized way, purchasing meets its objectives and contributes beneficial to a company's success. Monczka et al. (2009, pp. 38-40) defined six main objectives. First the supply continuity, which supports the needs of operations, physical distribution, engineering and technical groups, by providing raw materials and information about these. Another objective is to manage the purchasing process efficiently and effectively, that is, the continuous improvement of utilization of resources. Resources are for example employees and the available budget. Thirdly, develop supply base management, i.e., the selection, development and maintenance of supply. This also includes relationships with external suppliers and developing satisfying supply sources. Next, the development of aligned goals with internal functional stakeholders is an objective. This is done by close communication and collaboration between different departments of a company. The fifth objective is the support of organizational goals and objectives, which can be much influenced by purchasing. So, purchasing is a strategic asset that influences performance of the company. The sixth and last key objective is the development of integrated purchasing strategies that support organizational strategies.

While there is a lot of literature on purchasing and on Industrie 4.0, papers that are concerned with the correlation are rather absent. This statement is supported by Torn, Pulles and Schiele (2018, p. 2), who performed a literature review and found no relevant literature.

2.5 Introducing a Maturity Model to the Implementation of Industrie 4.0 in Purchasing

To diminish a lack of literature, Torn, Pulles and Schiele (2018) published a paper that introduced a maturity model. Applying this model makes it possible to see what stage a company is with an end-to-end implementation of Industrie 4.0 concerning its purchasing activities. This model consists of eight stages. Starting with (1) a coherent Industrie 4.0 strategy for the company and purchasing activities, (2) the readiness of processes, (3) a connection to the physical level, (4) automatized and autonomous payment process, (5) real time transparency is in place, (6) features are used for sourcing and data collection and whether (7) suppliers and (8) employees are prepared and willing. To recognize the progress along these stages better, a system of four levels was introduced. Level one means that there is a basis for the stage or some pre-mature implementations and level four means that the stage is entirely fulfilled, and Industry 4.0 features are implemented.

3. RESEARCH QUESTION

Multiple scientific papers suggest end-to-end integration is a main issue of Industry 4.0 (Kagerman, Wahlster , & Helbig, 2013, p. 6) (Brettel et al., 2014, p. 40) (Wang et al., 2016, p. 2). This means including all activities of a value chain, and applying Industrie 4.0 features throughout all departments of a company, including purchasing. While purchasing has increasing strategic importance (Chen, Paulraj, & Lado, 2004, p. 1) it also links internal and external operations, thus dealing with suppliers. Building and maintaining good relationships with suppliers helps to create new capacity and capability (Bag, 2018, p. 180). Thus, is important for the competitive advantage of a firm.

When recognizing this importance, the question comes up to what extent purchasing departments can implement features of Industrie 4.0. In respect to the company at hand the research question formulated is:

RQ1: To what extend does Scania apply Industrie 4.0 throughout its purchasing activities?

3.1 Sub Questions

Industrie 4.0 is a development that is just starting and most changes still lie in the future (Drath & Horch, 2014, p. 58). So, to expect a full integration in the purchasing department is quite ambitious. To have a better idea about the progress and expectations, two sub questions give better insights.

RQ2: What maturity stage is the company in, concerning implementation of Industrie 4.0 in their purchasing activities?

RQ3: What is the potential of the purchasing activities considering Industrie 4.0?

4. METHODOLOGY

The research for this thesis will be a qualitative research. It is a case study, and the focus is on a single firm. To do research a data gathering method must be practiced. In this case it will be done in form of interviews.

The first interview was conducted, in person, on the 23rd of May 2018 with Daniel Gobbi, a purchasing manager of Scania at the assembly location in Zwolle, the Netherlands. He has been working for Scania for 15 years in Brazil and is now situated in Zwolle for two years.

The interview was divided in two parts. First a semi-structured interview with questions about the purchasing processes of Scania. The questions were set up so that some broad information about Scania's purchasing

department would become clear and information could be gathered that helps solve the research question. Depending on whether Scania applied Industrie 4.0 methods the interview was focused more at the present state and on future expectations. In the second part of the interview the respondent was asked to rank the company based upon 8 questions. These correspond to the maturity stages designed by Torn, Pulles and Schiele (2018) making it is possible to get more information on their application and the progress of Industrie 4.0. The interview was recorded, so that a clear and complete transcript could be written. All questions, the ranking and the full transcript can be found in the Appendix.

The interview was prepared by writing a clear interview guide. This protocol consists of an opening and closing statement, the key questions and the ranking. During the preparation, probes and possible developments were thought about in order to get desired results. As the first part was semi-structured the prepared questions were more used as a guideline and not as a strict agenda.

After collecting this data and knowing more about Scania and its purchasing activities it showed that some more broad or even technical aspects about their approach to Industrie 4.0 was necessary. The department named Digital Factory was contacted. This department is part of Scania's Global Industrial Development and has smart factory as one of its main projects. It is located at the headquarter of Scania in Södertälje, Sweden. In this department new technologies related to Industrie 4.0 are evaluated and attempts to implement them are made. The contact was first established via telephone with Jim Tolman, an intern at Scania for 5 months, working on one of their projects. The actual information was then gathered in form of a semi-structures interview and via email contact. It means that from beforehand some questions were asked but the answers were textual and quite broad. Gathering this information via email was chosen so that the information could be checked and corrected by Fran Waker, his superior and the department manager. The questions and full answers are in the Appendix of this thesis.

The data was then analyzed according to a maturity model and other literature found on the subject. Because of the different sources it was also cross referenced to each other.

5. COMPANY

The companies contacted for this case study were chosen on very broad characteristics. A focus was on manufacturing companies, because of changing needs, there lies a high potential for Industrie 4.0 applications. These needs include rapid product introduction and production increase. (Wang, Torngren, & Onori, 2015, p. 3). Several companies were contacted from which only a limited number reacted openly and even fewer were interested in a purchasing specific research on Industrie 4.0, because of the absence of application of the concept. Scania replied very fast and very open, wanting to contribute.

5.1 Scania

Scania is a global provider of transport solutions, which includes products such as trucks and busses, but also services related to these. Its head office is in Södertälje in Sweden, where it was also founded as Vabis in 1891 (Scania AB, 2018). Sales and services are offered in more than 100 countries. Production facilities are in Europe, Latin America and Asia, while research and development are mainly done in Sweden (Scania AB, 2017, p. 2). Relevant here is that the purchasing department in Zwolle is conducting purchasing activities at European level, excluding Sweden. Since 2014, Scania is a wholly owned subsidiary of the Volkswagen Group.

Its vision is to "provide […] customers with profitable and sustainable transport solutions that contribute to the success of their businesses" (Scania AB, 2017, p. 5). Additionally, it is stated to not only create value for customers but also for other stakeholders. Explicitly stated, these are employees, suppliers, owners and lenders, and society (Scania AB, 2017, p. 4). Another aspect focused on in their annual report is sustainability. Scania is working on reducing its impact on the environment and is doing so by continuous research and development and recently started experiments with electric trucks. Other core values are determination, team spirit and integrity, which guide actions and strategy, also named 'the Scania way' (Scania AB, 2017, p. 13).

To give a better impression on the size and values, some numbers of 2017 will be stated here. Scania's market share of trucks in Europe is 16.2 %, based on registrations. During the whole year 95,781 vehicles were produced, where quality and delivery precision were improved. An increasing trend of the last years is bigger investments in research and development. In 2017, 7.5 billion SEK (around €7.3 million) were devoted (Scania AB, 2017). Especially these investments show that Scania is eagerly working towards improving its products and services.

6. FINDINGS

6.1 Industrie 4.0/Smart Manufacturing Vision

The digital factory department of Scania works according to a laid-out plan. This is the form of a pyramid and defines steps of the implementation of Industrie 4.0. A visualization of this was received by the interviewee.

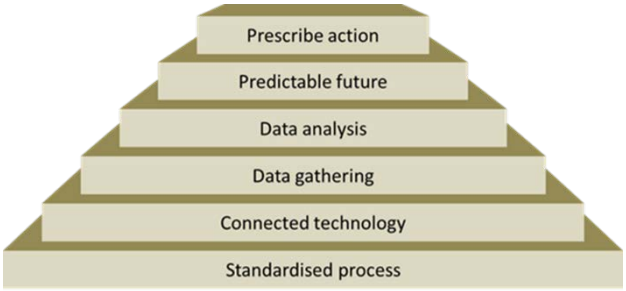

Figure 2: Smart Manufacturing Vision of Scania (Scania, 2018)

It consists of six stages starting with a standardized process, which is about the manufacturing of the trucks or

busses. It means that all production facilities of Scania work with the same machines, and the same input delivers the same result. The machines are all connected to each other but also to the internet and have sensors and computers that gather data. This could be data on malfunctions or errors in the production. The data collected is then analyzed and certain conclusions or insights might come up. This way the future productivity and eventual error rate can be predicted better and with more certainty. Based on these expectations the machine can learn and the process can be optimized. So all steps make it possible to prescribe the action in a better way.

It is necessary to follow the steps according to plan because the lowest stage is necessary to be achieved in order to fully practice the next one.

6.2 Examples of Application of Industrie 4.0 Features at Scania

A number of different practices that are categorized as being smart and thus belonging to Industrie 4.0 are handled by Scania. Projects are about the human-robot collaboration workstation design, which is the interaction between a worker and a robot in order to lighten the burden and comply to the needs of this worker (Cherubini et al., 2016, p. 1). Optimally the coordination and cooperation plays to the respective advantages of both parties (Wan, Cai, & Zhou, 2015, p. 137). One project that is smart, while focusing on people is the usage of smart clothing, which, while worn by workers, can detect bad posture and warn its wearer.

Another project that they are currently working on is to have automated guided vehicles (AGV) to transport necessary materials from the logistics room to the assembly, where it is needed. These transport units are intelligent entities that can make up the physical part of cyber-physical systems (Li, et al., 2015, p. 25). Similarly, robots fall in this category of smart entities, that become more intelligent with the integration of ICT in its computation activities (Wan, Cai, & Zhou, 2015, p. 137). The usage of VR is also explored. The goal is to create a Multiplayer Virtual reality to support factory layout planning. To use this for the construction and reconstruction has brought benefits already. While buying a new machine the plans of it are sent in a 3D model by the supplier and that can be put in a virtual landscape of the factory. That way a planning error that was not visible in the technical drawings was detected.

6.3 Purchasing Process of Scania

The purchasing process of Scania always starts with an employee making a request. The way this is done depends on the location. After this request is approved by a manager, the purchasing department starts its process. The request is analyzed into detail so that all specifications are clear when entering the market and asking for quotations (also called request for quotation, RFQ). Relevant suppliers then propose such a quotation. The next step for Scania is to equalize and compare these quotations. Without equal starting points the comparison would be biased and would suffer. At this stage of the process no supplier is excluded yet, and negotiations with all relevant suppliers are started. Depending on the outcomes of these negotiations a supplier is chosen. Criteria for this decision include price, quality and lead time. In some cases an additional step is required. As Scania belongs to the Volkswagen group the purchasing department has limited spending power. The purchasing department in Sweden can spend €750 thousand autonomously and at all other locations of Scania a purchasing department is allowed to spend up to €250 thousand. If the purchase exceeds this amount a proposal must be submitted and presented to Volkswagen. Subsequently, after this proposal is accepted, the purchasing process can continue. A final approval of the responsible manager at Scania is needed and then the product can be ordered.

When it is necessary to fill up the stock at hand in production, the process is faster and partly automatic. A person must submit a notice that stock is getting low and consequentially a new order is placed by the purchasing department.

6.4 Categorization as a New Purchasing Strategy

In the interview a new strategy for purchasing was explained. This strategy was defined after multiple brainstorm sessions with internal stakeholders on how purchasing will be in the future and is now being implemented in Europe and Sweden. These categories define which parts of purchasing need the most resources and attention. The main demand of this project is to make purchasing processes and employees work more efficient. In Latin America this strategy is already implemented and the timeline of the implementation in Europe is to be complete in January 2019. The categorization is in form of a pyramid and in the following section the groups will be explained.

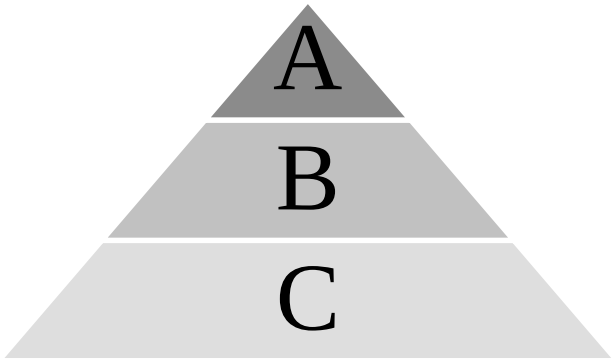

Figure 3.: Categories of products/services applied by Scania

6.4.1 Category C: low value

In the lowest category of the purchasing levels will be products and services that require investments below €50 thousand. Here the goal is to standardize all orderings and make them faster and easier by using a catalogue and having a short line with suppliers. With this it will be possible to have no more human resources involved in the process.

6.4.2 Category B: medium value

This product class is higher valued. It requires some people to work on, but the value that the products or services add is not high and the strategic value of these activities is modest.

6.4.3 Category A: high value

The highest valued products fall in this category. These products not only require big investments but also have a strategic importance for the company. The goal is to have many people allocated to this product group and thus make smart decisions on how to handle these big investments. Part of allocating people to this group will be to provide trainings in order to make employees capable of making strategic investments.

6.4.4 Benefits and changes of the new strategy

The main goal of this new strategy is to make everything more efficient. Especially products from category C will be processed faster and with less errors. For Scania this new categorization provides a better balance of resources, which is manpower in this case. It is not necessary for employees to spend any more time on low scale activities that do not add strategic value to the company. So, the overall focus of the purchasing department shifts to strategic, high value decisions.

Clearly, this reorganization also brings changes to the workplace. While a thought might be that less employees are necessary, in Brazil, where this categorization is already implemented, there eventually was nearly no decrease in employees, because the number of big investments increased. What requires for the employees to be educated on strategic sourcing and develop capabilities for important highly valued decisions

6.5 Applying the Maturity Model for Purchasing

Additionally, to some open questions, there was also a ranking provided with questions that correspond to the stages of the maturity model by Torn, Pulles and Schiele (2018). It showed that because of the categorization of products and with that, different processes, it is hard to make a broad ranking. As products from category C ask the least human attention, the ranking was filled in with this category in mind.

Table 1: Answers along the stages and levels of the maturity model (Torn, Pulles, & Schiele, 2018)

Stage	Level 1	Level 2	Level 3	Level 4
1. Strategy				
2. Processes				
3. Physical				
4. Pay				
5. Controlling				
6. Sourcing				
7. Suppliers				
8. Employees				

The answers are quite spread. Some stages are fulfilled more and others still show potential to improve. The reason for ranking the implementation accordingly will be explained in the following section step by step.

The first stage is not fulfilled totally. While there is a strategy for Industrie 4.0 and purchasing is recognizably working towards a situation where this strategy can be applied, Industrie 4.0 is not a common term in the purchasing department.

The second stage is about the processes in the purchasing department. The categorization explained earlier is working towards more standardized processes on a global level. Especially for the processes in category C a high amount of digitalization and automation are at place. The other categories require more case specific attention and manpower.

Third is the connection between a computational and a physical system. The category C products are ordered via a catalogue that directly orders it at the supplier. While the purchasing process starts with a request, from that point it is automated and no more human interaction is necessary.

The payment process, which is subject of stage 4, is fully automated at Scania. In this case it is not dependent on what kind of product. Internally, the number of products ordered and the coherent price is calculated. When the invoice from the supplier is received it is automatically checked whether this fits with the expected numbers. When everything is according to the expectations the payment process is finished without any further interactions. In case there is an error an employee of the finance department must check what causes it and corrects it.

The fifth stage has an internal and external aspect. Internally real-time transparency cannot yet be applied. A lot of the processes still need human interaction to start, thus a person needs to recognize an upcoming issue. An external level in this situation means that there is a cooperation with a supplier. Controlling an order is still quite difficult. While in some cases the progress and the estimated time of arrival are constantly monitored and the supplier communicates it with Scania, this is not the case for every supplier. Even though some monitoring is done it is often not in real time, and no full transparency can be guaranteed in most cases.

The sixth stage is on whether the strategic sourcing process is supported. Here, this is fully fulfilled because the respondent stated that the purchasing department has full decision power on which supplier to choose. Even though a different department submits a preference, the purchasing department is making the final decision concerning supplier selection.

As earlier mentioned, suppliers play a role in the implementation. Depending on the relationship with Scania the willingness to openly cooperate varies. It also depends on other aspects, such as size of order and amount of detail requested.

Stage eight of this model is about whether employees are capable and willing for changes. Scania is currently working on educating its purchasing employees in

coherence with the new purchasing strategy. Trainings and workshops are organized, so that employees can contribute and fulfill the strategic expectations of Scania. Conclusively it can be expected that with these actions the employees will be ready or will be trained for this next new implementation.

6.6 Inhibitors of Industrie 4.0 in Purchasing

Employees, have a lot of influence on a company and might also fulfill the role as inhibitors. The current knowledge about Industrie 4.0 is not only low but sometimes even wrong. Often developments from the third industrial revolution are understood as being part of Industrie 4.0 while the smart component of entities is not understood commonly. Possible changes are very specifically seen for the department they are working in and it might not be easy to make someone understand other benefits that come with the application. So not being open to the new technologies and eventually being afraid of future developments is a struggle when changing some part of the company.

It was possible to identify another inhibitor while talking about the current change of purchasing strategy. The size of Scania, makes the implementation more difficult. For example, while the new categorization strategy is already applied in Brazil, the timeline for the European facilities is only to be finished in January 2019. So there are different times of implementation and it cannot be done simultaneously in all locations of Scania. With Industrie 4.0 applications on the other hand, it is important to have it standardized and all processes following the same protocol. When such an implementation is applied in the same way as the new purchasing strategy, so area by area, the implementation might take up a long time.

6.7 Enablers of Industrie 4.0 in Purchasing

Specifically, for purchasing there is a department that monitors processes and functions and is continuously working on improving these. This department is working globally as one goal of Scania is to standardize its processes on a big scale. Reaching this goal enables the company to implement more and more automated processes and incorporate Industrie 4.0 features throughout the whole company.

Scania is eager to develop and improve, this can be seen by the amounts of money that are put into research and development. This ambition is a big enabler and is crucial for any progress.

Another enabler for Industrie 4.0 is the new strategy that Scania is working to implement. Evaluating the products and dividing it into categories, it is possible to recognize standardized processes that have high potential for automatization. This can be used as a starting point for Industrie 4.0 application in purchasing.

Simultaneous to the implementation of the new strategy, Scania is investing in training its employees. By following workshops, they will be ready to work in the new environment. Kotter and Schlesinger (1979, p. 5) already defined education and communication one main strategy to prevent employees that might resist to change.

7. CONCLUSION

During the data collection it showed that a lot of thought is put into future developments and multiple projects concerning Industrie 4.0, or smart manufacturing as Scania calls it, are supported. There is a clear strategy along which the development department is working which shows that Scania is out of the pre-mature stage and is working towards a clear goal, which is full implementation of smart manufacturing.

While Scania is putting a lot of effort in the technical aspects of implementation of Industrie 4.0 the purchasing department is still lacking attention. During the contact with purchasing managers it was visible that the knowledge about this concept is limited. Although the new categorization shows that the company is thinking about the increasing automatization of purchasing activities, it is only a pre-mature stage of a possible end-to-end implementation.

The results show that answering the sub-question on whether Scania follows the maturity model of Torn, Pulles and Schiele (2018) it is quite interesting to see that, except for some outliers, all stages are at similar levels of implementation.

Additionally, when looking at the potential of Industrie 4.0 in purchasing the categorization of Scania is striking. It especially shows that improvement is desired in all departments, and Scania is thinking about future developments. While products with low value show high potential to be fully automatic and an implementation of Industrie 4.0 features seems possible it is different for high value projects. Here, the opposite is done and a lot of human capital is allocated there. This allocation also requires financial resources and it is probable that there will be no changes of strategy soon. So, to conclude, processes that interfere with category C have high potential and with increasing value the potential is decreasing.

While looking at the current usages of Industrie 4.0 at Scania the example of using a Virtual reality landscape to plan a factory showed one clear benefit for purchasing. The product can be tested in a way. So, it becomes clearer on what the specifications of a product are and this can then be communicated to the supplier. So, while the Industrie 4.0 feature is not applied to the purchasing process it still has influence and can reduce the amount of errors while ordering.

7.1 Crosslink to literature

In literature the opinion of the importance of purchasing changed a lot over time. The opinion that purchasing is of non-strategic nature was present (White & Hammer-Lloyd, 1999, p. 29). John Ramsay (2001) states that purchasing functions are rather operational than strategic and only in exceptions contribute to gaining or maintaining a competitive advantage (Ramsay, 2001, p. 262). Just in the past years this opinion is changing on a broad scale. Starting with the opposite opinion that strategic purchasing provides potential for competitive advantage. A literature review by Narasimhan and Das

(2001, p. 607) suggests that external and internal purchasing activities should be integrated in the firm and a successful integration can increase competitiveness. Monczka, et al. (2009, p. 5) have a similar opinion, and judge the development of progressive purchasing approaches and strategies as help to build or maintain a competitive advantage. Paulraj, Chen and Flynn (2006, p. 118) found that strategic purchasing can have profound impact on supply chain performance, judged from the supply-side not the customer-side. For one, it is clear that purchasing is important to the financial aspects of a company. In manufacturing the percentage of purchases to sales averages 55% (Monczka et al., 2009, p. 7), which shows the influence of suppliers on financial results of a company. Additionally, purchasing contributes to the success of other aspects of production, such as product and process design. It is found that companies who involve suppliers early achieve an average 20% reduction in materials cost, 20% improvement in material quality and 20% reduction in product development time, compared to companies that do not (Monczka et al., 2009, p. 7).

This shows the importance the purchasing function fulfills within a company and it should be considered when making strategic decisions or setting up a future strategy. Scania is doing this with the clearly defined strategy and a clear action plan on how this should be implemented.

Already since the first introduction of Industrie 4.0 three ways of integrations are mentioned. Next to horizontal integration through value networks and vertical integration and networked manufacturing systems it also includes the earlier mentioned end-to-end digital integration of engineering across the entire value chain (Kagerman, Wahlster , & Helbig, 2013, p. 6). It shows that this integration in all departments of a company is in progress but might still take some time to be in the perfect state-of-art.

Virtual reality has longer been applied to parts of the process from a design to the actual product. It provided a way to optimize the design and test it on aspects such as functionality or human interaction (Mujber, Szecsi, & Hashmi, 2004, p. 1835). Especially for manufacturing it changed traditional approaches (Ong & Nee, 2004, p. 4). In the future hybrid prototyping will be used more, as a combination between a virtual prototype and a model, which increases realism of virtual simulations (Zawadzki & Zywicki, 2016, p. 109). Its application provides a tool for testing and evaluating ideas more specifically, and additionally decrease time to market and production cost (Mujber, Szecsi, & Hashmi, 2004, p. 1838). Consequentially these two main challenges for production can be approached.

8. DISCUSSION

Data collection was mainly focused on European facilities, but intensity and efficiency of purchasing activities and strategic involvement varies between country groups (Yang et al., 2013, p. 20). So, the research is limited in its scope and might not be beneficial to companies in other regions.

To make the conclusion better applicable, more people, working at Scania or other companies, should be interviewed. This way it can be more visible to what extent the application of Industrie 4.0 in purchasing is in progress.

Additionally, it might be that because of high competitiveness some data might not have been shared as openly as expected. While confidentiality was mentioned when receiving data from the future factory, the data was shared without any further specifications. So, that suggest that there are more projects that are done, that might not have been shared. All data received here was non-confidential. Seeing that the environment is dynamic and very competitive (Deloitte Center for Industry Insights, 2016, p. 3) it can be that the recommendations might be obsolete relatively fast.

Repeating this study at a later point in time is another suggestion. This way the actual developments could be tracked and further insights can be found. This would clarify eventual benefits of the integration of Industrie 4.0 in purchasing.

8.1 Limitations

The data collection was done by interviewing specific people, and while some data was double checked, not all was. This data could be biased because of missing overview of the company's activities or missing knowledge of Industrie 4.0. The time restrict on this thesis made it not feasible to interview multiple purchasing managers of Scania, and therefore the view is quite narrow. Having more data sources would increase the validity of the results.

On another approach, conducting a quantitative research could offer different results. Due to the uncertainty of the results from beforehand a clear coding was not possible but in further research a quantitative coding might be possible to apply and differences in the analyses might appear.

9. ACKNOWLEDGMENTS

I would like to thank everyone that supported me and helped me with finishing my thesis. My appreciation especially goes to Jim Tolman and Daniel Gobbi who invested time in helping me and providing me with a lot of information. I thank my supervisors for the helpful feedback and tips, especially when I was stuck. Finally, my friends and family are thanked for being interested and wanting to help at every moment along the way.

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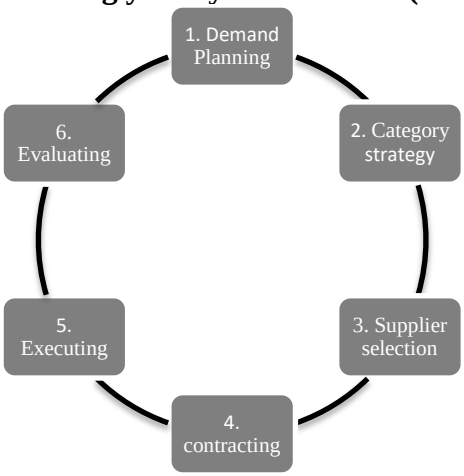
11. APPENDIX

11.1 Purchasing year cycle as seen in (Torn, Pulles, & Schiele, 2018, p. 5)



11.2 Interview questions, Daniel Gobbi

- Does Scania have purchasing processes that qualify as Industrie 4.0 processes?
- What changes did these changes bring to the purchasing process?
- What is the timeline of these implementations?
- Is it possible to see benefits from these implementations?
- What are enablers of Industrie 4.0 in purchasing in your company?
- What is holding back the implementation of Industrie 4.0 in your company?
- Is the purchasing department crucial in overall strategic decisions of your company?
- Are there any succeeding steps planned in with the introduction of Industrie 4.0?

Additionally, I would like to ask you to rank Scania on the following questions and stages:

	Stage 1	Stage 2	Stage 3	Stage 4
Is there a consistent Industrie 4.0 strategy for the firm and for purchasing?				
Are the processes standardized, digitalized and automated?				
Is there a connection to physical systems?				
Is the payment process automated?				
Is there complete, real time transparency				
Is the strategic purchasing process supported?				
Are the suppliers available, prepared and willing?				
Are the employees available, prepared and willing?				

11.3 Openings statement (interview)

Nice that this meeting is possible.

To begin with, I would like to create a common understanding of the concept of Industry 4.0, so that we are on the same page. For my paper I will use three pre-defined characteristics. The first ones are Cyber-physical systems, which are the systems that connect physical assets and computation capabilities. A second characteristic is the use of Autonomous self-organizing systems, that are able to react to novel situations and do not have an inflexible pre-defined path. The third one I am going to apply is the machine to machine communication, which means that machines communicate directly without involving a human interface in a process. So, I am especially interested in processes that fulfill all these three characteristics, but processes that fulfill them partly are also interesting.

Do you have any questions about this?

Then I would like to ask you some questions

11.4 Closing statement (interview)

Thank you. According to your answers I will be able to analyze how far your purchasing department is with applying Industry 4.0.

I will let you know when I am done with my thesis and will send you a copy, if you like.

Thank you for your time.

11.5 Levels of maturity

Stage 1	A particular best-practice activity/tool/method is known within the organization.
Stage 2	A position or a person is assigned to perform the task.
Stage 3	The process for completing the task is defined and documented as well as applied.
Stage 4	Cross-functional integration in the company is assured while basic requirements are met.

11.6 Interview transcript Scania Nederland BV (23.5.2018)

Q: What does your purchasing process look like? Are there any that are autonomous?

A: I would say that in global perspective Scania, talking about purchasing, we don't have this autonomous. It is always necessary for some human interaction to make the finalized order or approval.

The purchasing process should start with a requisition in the beginning. If you need to buy something you have to request according to the manner of the region, it can be a […], automatically in a system you can request a computer, hardware, any offices supplies, doesn't matter, you need to start with a request. A requisition must be approved by the leadership inside Scania according to some limits. After this approval they come to the purchasing department and we have our own process, we analyze the requisition, everything is clear or not and we have to go deep a little bit about the specification. If you want to buy something you need to specify what you really need in detail. Depend on the complexity but it should be a demand specification as we say. Then, go to the market, see potential suppliers to deliver what you need, that can be a product or can be a service and ask for quotations. We call this RFQ, request for quotation. We go to the market asking for quotations and we receive quotations.

First of all, we must equalize, compare. We always say compare apples with apples. Io supplier quote at different scope, you can't compare them. It does not make sense to have this in a competition. So, every

supplier must quote the same thing, the same specification, not more or less. If you are in a good level, the same level, you can start negotiations, with all suppliers. No supplier is disqualified until this moment, so we have to give all the suppliers the same opportunity to negotiate. After that we decide for the best price, the best solution, the best lead time, delivery, quality, everything. According to the limits we must present it to Volkswagen group companies, because Scania belongs to Volkswagen group. We have different levels to approve. Local purchasing managers can approve 250 000 euros, Scania headquarter in Sweden can approve 750 000 euros, above that we start to present in Wolfsburg.

So, what is approved. We are approving […] the awarding supplier, we show all the quotations, the prices and that's a proposal.

When it is approved we start with the real system. We enter it in our system, the purchasing system, it belongs to IBM. Fulfill the purchasing order and the respective manager must approve it in this system. That is how it works when you need to buy something.

For the automatic process we have a warehouse, storage, and people in the warehouse need to ask, is the stock level good enough or do we need to buy something else. This goes to purchasing and we buy. So, there is always some human involved.

Q: So, there is always a request?

A: Yes, someone is asking

Q: So about actually applying Industrie 4.0 processes, it is not yet in purchasing you say?

A: In production it is present probably but not in purchasing. We have started to have a lot of brainstorm on how the future of purchasing will be.

Q: So, is there already a strategy for purchasing?

A: Not about the system but about the process. We started to use an ABC classification. Depending on how much we spend on a product or suppliers we will classify the products in categories of ABC. Category C means that the spending is below 50 thousand euros, it should be a really autonomous and automatic system. That means that everything is in a system, and it is possible to directly ask the suppliers and then the supplier will deliver. Call-of we say, it is electronically ordered, so easy to buy. Above this category is normal sourcing, a normal sourcing process and even above this is a really strategic sourcing. This means that most of the people are put to work in the top of the pyramid.

(draws an example)

A is high spend, C is low spend. In category A there work no people, only a system. In category B there are working a few people, not many. In the highest category work a lot of people, work with really high values and strategic decisions. So, this is our strategy on how to work in the future. Do low spend will be very automatic.

Q: So, for category C is standardized and automated?

A: Yes, like a catalogue. It should be easy to have a supplier, you have a supplier, you have the contact and there is a clear price list. So also, a list of product assortment, that will be in the system and users can request.

Q: So, there is a connection in real life between the computer and a physical aspect of the system?

A: Yes

Q: Is the payment process that corresponds to this also automated?

A: Yes, all payment processes are automated. It does not matter which of these levels a product is in. All payment flows are automated.

Q: So just for everything

A: Yes, if you buy something you have to issue a purchase order with a number, reference, items, price. So, when the supplier sends an invoice there is an automatic cross-matching and the payment is done. If it is not matching, so something is wrong, like the price is not matching, a person has to check this deviation.

Q: So, the control is done by a person again?

A: Yes

Q: Ok, during the process, including the process of the supplier in how far can you check how it is going? Is the process transparent and can you check it in real time?

A: That depends on the supplier, and on the complexity of what we are buying. Concerning receiving goods it is very transparent.

Q: In how far does the purchasing department influence decisions? Also, strategic decisions?

A: I would say that we are very responsible for decisions. We have the power of attorney I would say, to decide.

Q: So what kind of decisions are that then?

A: Related to a supplier. It is related to us and not with any other internal customers. We often receive requisitions that say that there is a need to buy something and also requesting a specific supplier. We can say no to that. We will start our process with going to the market, and if the recommended supplier has good prices and is really competitive, ok. But if we find something better in the market I will buy that.

Q: Are the suppliers willing to cooperate with you very closely? Also, maybe have products personalized?

A: Depends on what we are buying and on how much.

Q: What do you think about Industry 4.0 in purchasing.

A: I think that an implementation is possible.

Q: Is there any part that is especially supporting developments?

A: For purchasing, on the global stage we have one specific department, which is busy with processes and systems. They are looking for continuously improving processes and systems as well. So there is a specific department to help us and support us to make this kind of things happen.

Q: So, what will the next step in developments be?

A: The ABC categorization. Today we have the strategy and we are working to implement this. The strategy is very defined it is not only in mind and now we are working and implementing towards this goal.

Q: Is there also a timeline for this?

A: January 2019. That is my assignment, that is why I am here.

Q: And this strategy is for purchasing in Europe only?

A: Yes, I have a partner that is doing the same in Sweden.

Q; But not in other regions?

A: Brazil has already done it. So, we are standardizing the process worldwide, so everyone is on the same level.

Q: What are main benefits of this new system?

A: First, balanced resources, people I mean. Put the focus where it is necessary. So have dedicated people work where the money is. The low amounts can be done by a system and done fast. There will be a shorter lead time for these kinds of products. And have resources enough on strategic decisions.

Q: So, is there also a cost aspect to it?

A: Mainly the goal is efficiency.

Q: What changes does this implementation bring with it? Especially for the people?

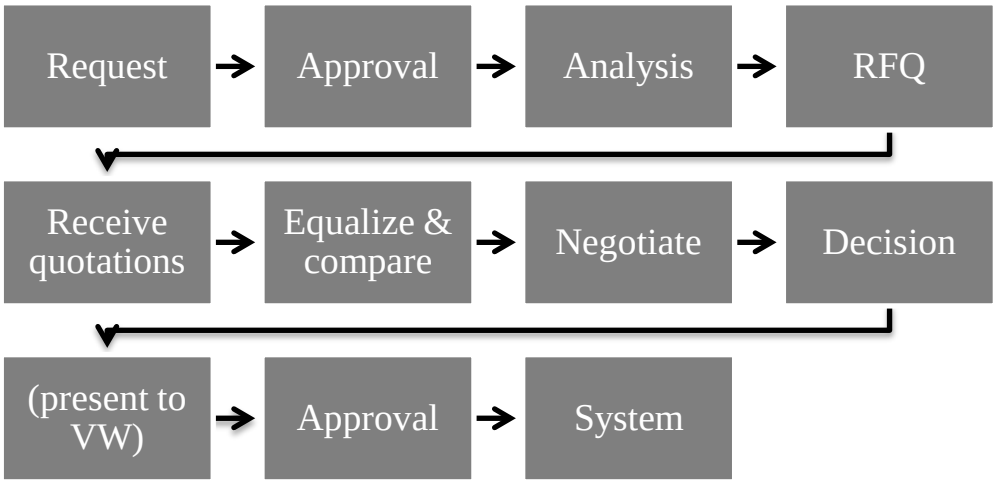
A: Actually, not that big changes but people will also become more efficient. Efficiency is the demand word for this system. They will spend less time on things that are not necessary, or that are quite simple, low complexity. But they will be helped to develop and be able to work with high spend, high amount of money, and to work globally in a strategic way. There will be a lot of trainings to develop skills of purchasing.

But eventually also effect of reducing the number of people. It is under evaluation how many people we really need in the organization. This is very countable and can be profitable for the company.

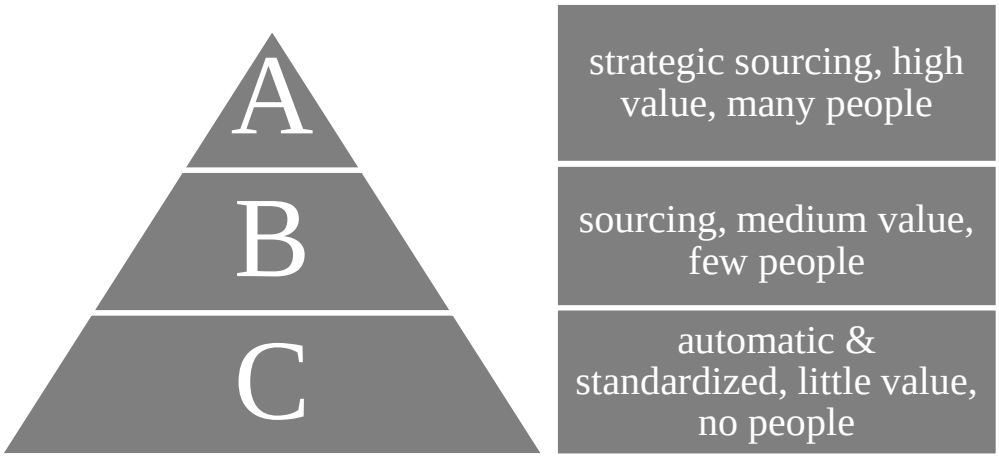
Q: In the regions where this categorization is implemented, did it show that less people are necessary?

A: Actually, no. It was kept the same. Investments are increasing so we have more people working in the high value projects. So a reduction in the C category is balanced by increasing the amount of people in the A category. The headcount is more of less the same.

11.7 Purchasing process of Scania



11.8 Product categorization



11.9 Questions Digital Factory Scania

Is there a clear vision on how to use Industrie 4.0 at Scania?

Examples of processes?

How do these processes connect with purchasing activities?

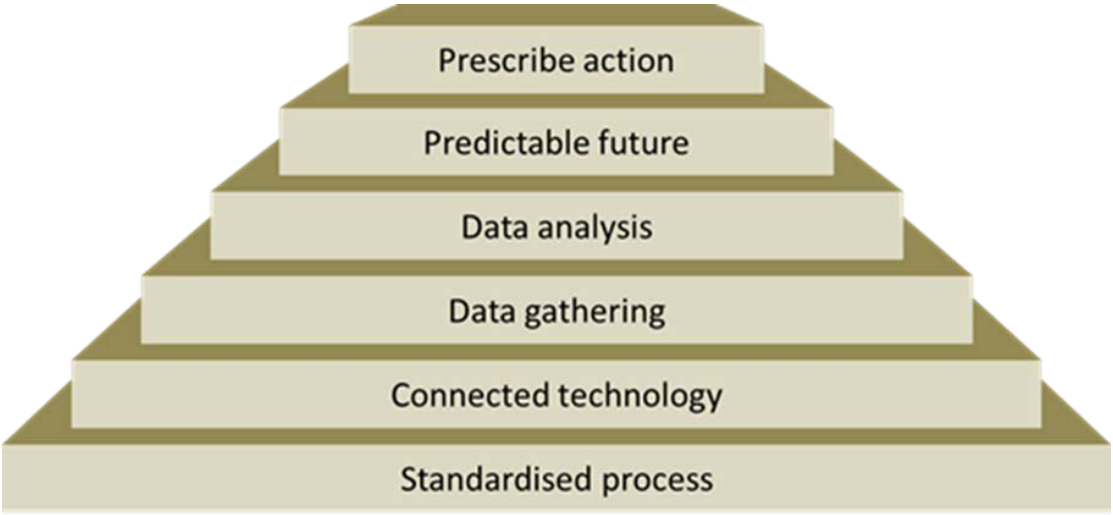
Which processes would benefit from a connection to purchasing?

What potential lies in this connection?

11.10 Answers Digital Factory Scania (08.06.2018)

Dear Lea,

We work at the Digital Factory (part of Global Industrial Development), and one of our projects is Smart Factory. We evaluate new technologies related to Industry 4.0/smart manufacturing and try to implement them. We work according to the following pyramid (Smart Factory Vision).



Some projects include: Human-Robot Collaboration workstation design, Prediction of variation from heat treatment using Machine Learning, Automatic point cloud scanning robots to map a factory floor, Multi player VR to support factory layout planning, painting robots, tracking tools throughout the factory floor, AGV's that can bring material from the logistics room to assembly and smart clothing that can detect bad posture and warn operators.

So: some assembly processes that involve lifting heavy parts will require different, less specialized robots, if there is good Human-Robot collaboration. The process of planning a new factory (construction or reconstruction) will be informed by Multi player VR, so this indirectly would affect purchasing. Also, I recon there will be a future trend of Scania increasingly buying computing power, while the acceleration of buying mechanical power would not increase.

I am not sure if the processes would benefit from a connection to purchasing. I don't know a lot about purchasing; Franz can you help us with answering the last two questions?

Kind regards

Jim Tolman

11.11 Smart Factory Vision explained in detail via telephone (15.06.2018)

De bodem van de Pyramide is een standardized process, dat gaat dan dus over het process van het maken van een truck of bus. De motor moet worden in elkaar gezet en daar zijn bepaalde machines voor nodig, we gebruiken in elke Scania Fabriek dezelfde machines en als je op dezelfde knop drukt gebeuren er de zelfden dingen. Connected technology betekent dat het geen machines zijn van de jaren 90 maar het zijn moderne machines die sensoren hebben en misschien ook een computer, die daardoor weten wat er aan de hand is. In plaats van dat iemand naar de machines moet kijken hebben ze zelf wat informatie en ze zijn verbonden met het internet. AL die machines gaan data verzamelen, dus je hebt ook server ruimte nodig om al die data te kunnen verzamelen. Dat gaat via het internet. Data analysis gaat meer over iets doen met de data, bepaalde processen gaan misschien weleens fout en dan kan dat geanalyseerd worden. Als er een onderdeel van het lopende band komt zijn er 96 % goed maar er zijn ook altijd een paar mislukt. Het is heel lastig in te schatten wat goede onderdelen zijn en wat niet, van tevoren. Ze worden wel getest, en afgekeurd in een ander machine. Die data of het goed is of niet kan dan terug worden gekoppeld met instellingen van de productiemachine en daarvan kan je leren. Dat heeft dan ook te maken met de toekomst voorspellen. Dan kan je dus ook zeggen voor dat een onderdeel een proces in gaat en is er een kans dat er iets mis gaat en kan er iets anders mee gedaan worden. Op deze lessen kunnen dan beslissingen gebaseerd worden voor de toekomst.

11.12 Additional information received by telephone (14.06.2018)

Voor purchasing wordt bepaald wat er gekocht mag worden en wat er uitgegeven mag worden door Volkswagen group. Dus niet door Scania zelf, Scania Södertälje mag het meest uitgeven maar alle anderen fabrieken mogen minder uitgeven.

Voor IT hebben ze een systeem van Order IT, die dan met purchasing uitkiezen welk product er besteld gaat worden. Dan kunnen zij zeggen wat voor een soort computer er nodig is. Ze hebben voor elk soort

computer een model die je via een intern systeem kan bestellen. Als ze meer met VR zouden doen moeten er nieuwe afspraken en maatstaf komen. Dan maakt purchasing afspraken met suppliers van VR installaties. Maar dat is dus vooral vanuit Volkswagen.

Ik heb ook met iemand gepraat die een nieuwe machine moet kopen uit de afdeling assen dus de ass van een Auto. Om zo iets te maken zijn er een aantal machines en er komt nu een nieuwe bij. En hij had 3D modellen gekregen van een fabrikant. Deze is dan in VR omgeving toegevoegd, en dan kon je bekijken hoe het is van binnen en van buiten. Toen hebben zij gezien dat er een deurtje niet open kon doen omdat er een ander onderdeel van de machine voor zat. Het was dus niet goed, en dat kon je op een technische tekening niet zo goed zien maar in de VR wereld wel. Dit veranderd wel de verwachtingen van een klant want er kan veel meer in het detail worden gedaan en de klant weet meer en beter wat ie wil en nodig heeft van een fabrikant.