UNIVERSITY OF TWENTE.

Faculty of Behavioural, Management and Social Sciences

Research Proposal – Master Thesis

Master of Science (M.Sc.) Business Administration

Purchasing & Supply Management

The use of digital technologies in purchasing and contract management of public organisations

---

Submitted by:	Alicia Weenink
	S2424525
1st Supervisor:	Dr. F.G.S. Vos
2nd Supervisor:	Prof. Dr. L.A. Knight
External Supervisor:	Mr. M. Haitsma
	Shared Service Center Ons

Number of pages:	54
Number of words:	18.796
Bibliography programme:	EndNote X9

Zwolle, 10 January 2022

Acknowledgements

After graduating from the University of Applied Sciences in Deventer, it was very tempting to look for a job. But a Master study in Enschede was a higher goal for me and I decided to invest another year in my education. It has been an interesting and challenging year, not only due to COVID-19 restrictions which had me stuck to my laptop for online lectures but also because I have not been able to meet my teachers and fellow students in person. Nonetheless, I am ready to go to work. Before I close the books and say goodbye to the University of Twente, I would like to express my thanks to the following people who have made it possible for me to achieve my goal.

First of all, many thanks to my external supervisor mister M. Haitsma for giving me the opportunity to start with this research at the Shared Service Centre Ons in Zwolle. I sincerely hope that the organisation will benefit from the outcomes of my thesis.

Secondly, a big thank you to my supervisor dr. F.G.S. Vos for all the useful feedback during my research and while writing my thesis. I greatly appreciate you took the time to guide and challenge me throughout this process. Your patience and experience helped me to increase my knowledge and grow personally as well.

Thirdly, all thanks are in place for prof. dr. L.A. Knight for your positive feedback and green light. Your view on public organisations was very valuable for my research.

Subsequently, my research would not have amounted to anything without the input from all the interviewees. Thank you to all of you for taking the time to share your experiences, insights and knowledge with me. It was a pleasure to (digitally) meet these professionals and learn from them.

Lastly, I cannot forget to thank my partner and my parents for their patience and their never-ending support during my Master thesis.

Abstract

Content research: Little research is conducted about the use of digital technologies in a public organisation overall. Moreover, there are no studies found that describe the application of these digitalisation methods in public purchasing and contract management activities. Nevertheless, the world is moving towards a more digital environment and the importance of using digital technologies increases. Besides, with the use of digital methods organisations can provide more effective and efficient services by reducing the number of mistakes and administrative work. Therefore, the purpose of this study is to provide an overview of digital applications that can be used in purchasing and contract management activities of a public organisation. Therefore, this research assesses the application of digital technologies along the Purchasing Process Model (PPM) from Van Weele.

Methodology: This study applies a qualitative research approach using interviews to collect data. Two research units are selected for the interviews. The first group are experts in different fields: public organisations, purchasing, and digitalisation. The second group are employees from public organisations that use digitalisation within purchasing. Due to COVID-19, the researcher was unable to perform face-to-face interviews. Therefore, video conferencing is used to conduct the interviews.

Findings: Research shows that digital technologies can have a positive impact on purchasing and contract management activities in a public organisation. The research concludes that e-Tendering Software, API Management Software, BI, Cloud Computing, OCR, Blockchain, IoT, RPA, and AI can all be applied in the phases of the PPM. However, some applications are more effective compared to others. Based on the results, the effort/impact matrix in paragraph 5.2 provides an overview of the required effort and the impact the digital technology has on the organisation. The results show that Cloud Computing must be the first step. Only when the organisation works in the cloud, more digital technologies can be applied. Subsequently, RPA and AI have the highest impact on the organisation and are therefore considered to be the most promising technologies. Both technologies can be applied in several stages of the PPM. RPA helps organisations to reduce repetitive administrative tasks. However, this technology only performs rule-based, well-structured tasks. On the contrary, AI is self-learning and continues to develop based on performances and is, therefore, able to perform activities that require human thinking.

Keywords: digitalisation; public organisation; purchasing; contract management; purchasing process model.

Table of Contents

Index of abbreviations

AAAI	Advancement of Artificial Intelligence
AI	Artificial Intelligence
ANN	Artificial Neural Networks
API	Application Programming Interface
BI	Business Intelligence
CM	Contract Management
CPS	Cyber-Physical Systems
EU	European Union
I4.0	Industry 4.0
IoT	Internet of Things
KPI	Key Performance Indicator
ML	Machine Learning
M&A	Merger and Acquisitions
OCR	Optical Content Recognition
PPM	Purchasing Process Model
RFQ	Request for Quotation
RPA	Robotic Process Automatisation
SRM	Supplier Relationship Management
SSC	Shared Service Centrum
USA	United States of America

Index of tables

Index of figures

1 Introduction: digitalisation is likely to change the purchasing process in public organisations

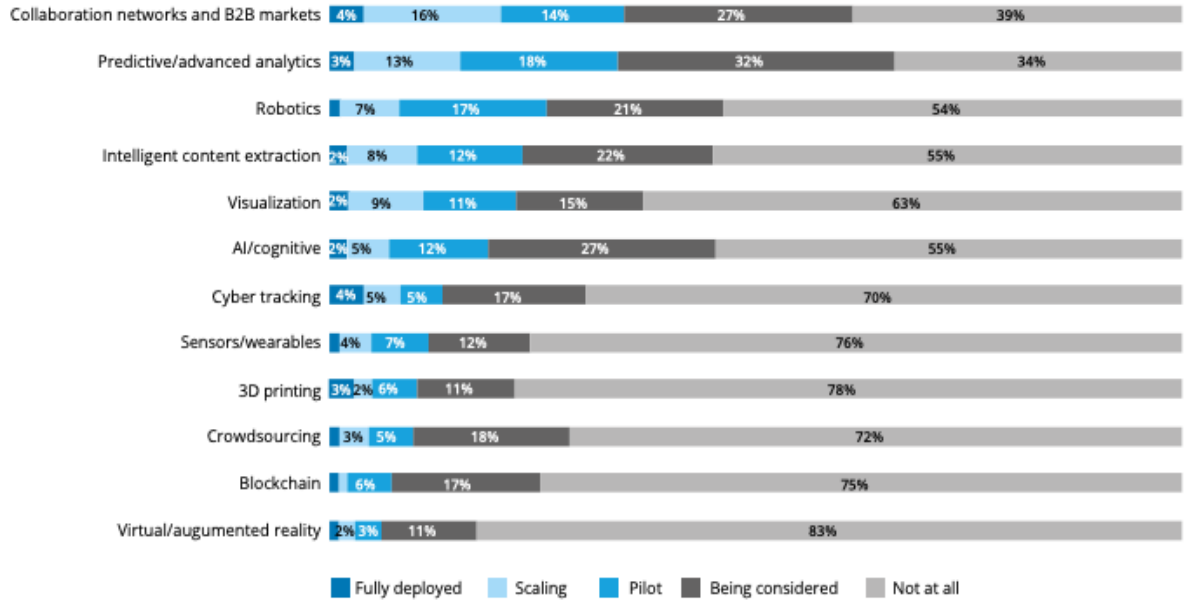
Over the past years, the world has moved toward a more digital environment. Technology has become a crucial part of our life. This change is driven by the increasing technological demand of customers. Firms respond by changing the way of doing business. Firms adapt their business models, processes, structures, and increase technological investments, which leads to a decrease in costs and increase the firm's efficiency (Kumar, Ramachandran, & Kumar, 2021, p. 1). "Digital transformation is generally the ability of organisations to provide more effective and efficient services, in line with the opportunities provided by rapidly developing information and communication technologies, and changing social needs" (Calp, 2020, p. 123). These new forms of technologies range from Internet of Things (IoT) to Artificial Intelligence (AI) and could be an added value in both "operational and administrative processes" in organisations (Weissbarth, Geissbauer, & Wetzstein, 2016, p. 4). According Kumar et al. (2021, p. 1), the most important "new-age technologies" are AI, Machine Learning (ML), IoT and Blockchain, of which AI is considered most promising (Kumar et al., 2021, p. 5; Tokmakov, 2020, p. 668).

Especially in the past years, the digital transformation has been translated into many organizations (Srai & Lorentz, 2019, p. 78; Tokmakov, 2020, p. 668). For example, the global COVID-19 pandemic gave a boost to the use of digital technologies in businesses. Many restrictions were published to reduce the spread of COVID-19 which has made it impossible for some organisations to organise meetings. This also affected public organisations (Tokmakov, 2020, p. 668). Also, the importance of collecting data and interpreting this, increases (Talhaoui & Mulder, 2019, p. 4). When data is correctly interpreted, an organisation can gain competitive advantage (Talhaoui & Mulder, 2019, p. 4). Additionally, speculations rise about the opportunities digitalisation has in purchasing, which are not yet developed (Srai & Lorentz, 2019, p. 78). For example, Talhaoui and Mulder (2019, p. 12) describe that the use of AI in purchasing can be an added value to an organisation.

Gartner releases the Hype Cycle for Procurement and Sourcing Solutions to give an understanding of the maturity and benefits of different technologies. The Hype Cycle of 2020 shows that the innovation of digitalisation methods continues in the procurement departments of organisations (Keck, Connaughton, & Sommers, 2020).

Innovation continues but The Deloitte Chief Procurement Officer survey of 2018 shows that few organisations of the researched CPO's have fully applied digital technologies in purchasing. For example, only 2% of the researched CPO's fully deploy AI in the organisation and even less have applied robotics or blockchain, as shown in figure 1. "Deloitte's view is that applying digital technologies to the procurement function will enable strategic sourcing to become more predictive, transactional procurement to become more automated, supplier management to become more proactive, and procurement operations to become more intelligent" (Umbenhauer & Younger, 2018, p. 29). This defines the opportunities to fully deploy digital technologies in the purchasing department of a public organisation.

Figure 1 Extent to which the following technologies are currently used in procurement (Deloitte,



Few purchasing professionals use AI in their daily activities as a result of a lack of knowledge about the opportunities and challenges (Mulder, 2019). However, the use of AI is not new (Sun & Medaglia, 2019, p. 2). Using AI in purchasing can lead to several opportunities (Talhaoui & Mulder, 2019, p. 14). For example, AI can lead to more problem solving, faster processing and more inputs (Kumar et al., 2021, p. 3). Also, value creation and gaining competitive advantage are important advantages of the use of AI (Calp, 2020, p. 123; Deloitte, 2020b, p. 11). More organisations implement and expand the use of AI (Calp, 2020, p. 123). Since 1998, AI solutions are being used for spend analysis, the best-known application of AI within purchasing. Also, contract management, negotiations, and the processing of invoices are new applications in purchasing where AI is being used

(Talhaoui & Mulder, 2019, p. 15). But AI also has several challenges which can be considered as a boundary for many organisations. For example, having a large amount of data to train the AI algorithm (Sun & Medaglia, 2019, p. 9). Within public organisations, challenges range from algorithmic bias to the privacy of data (Deloitte, 2020b, p. 11).

The application of digital technologies can differ between private and public organisations and therefore, results can be different. Knight et al. (2012, p. 17) state that "when comparing public and private sector procurement it appears that the demands on public procurement are greater and more highly varied than those on private sector procurement". Also, compared to private procurement, public procurement has to follow specific regulations to make sure that there is honest and open competition (Arlbjørn & Freytag, 2012, p. 204). Public and private procurement differ in external and internal demands, demands originating from the context, process demands and having multiple roles (Knight et al., 2012, pp. 17-19).

As mentioned before, applying digital technologies can have a positive influence when used in the purchasing department of the organisation (Talhaoui & Mulder, 2019, p. 14). However, there is limited research and knowledge about the use of digital technologies in public organisations (Senyo, Effah, & Osabutey, 2021, p. 1; Sun & Medaglia, 2019, p. 2). Most research is conducted within private organisations, for example in the automotive industry, financial services, and retail (Sun & Medaglia, 2019, p. 1). Currently, public organisations do not have enough experience with digital technologies such as AI and therefore consider this to be a boundary (Deloitte, 2020a, p. 4). However, public organisations do want to improve their productivity and look for opportunities with the use of digitalisation, since it has the potential to develop operations and increase human productivity (Deloitte, 2020a, p. 4; 2020b, p. 11). Therefore, the purpose of this research is to provide an overview of digitalisation methods that can be applied in purchasing and contract management of public organisations.

This thesis will aim to address these topics by defining the knowledge gaps. Therefore, this research is guided by the following research question:

"How can digital technologies be used throughout the purchasing process in a public organisation?"

This thesis aims to give more information about the digitalisation of purchasing and contract management activities in public organisations since little research is conducted on this subject (Sun & Medaglia, 2019, p. 2). This research will support future studies by providing an overview of the digital technologies that can be used within each phase of the Purchasing Process Model (PPM) designed by Van Weele. Therefore, this research will contribute to the academic field of public purchasing (Pūraitė, Adamonienė, & Žemeckė, 2020, p. 91; Sun & Medaglia, 2019, p. 2). The research will provide information about the application of digital technologies by following the PPM of Van Weele. Therefore, the process of Van Weele is examined and adjusted.

This research will contribute to practice by closing knowledge gaps between practice and literature. In addition, the research provides solutions to apply methods of digitalisation that are less discussed in the literature. This uncovers new applications and findings. Senyo et al. (2021) determine that public organisations have little knowledge about the application of digital technologies and the opportunities these have (p. 1). Therefore, this thesis will provide a starting point for public organisations to gain more information and to start with the use of digital technologies. As a first point, this research shows the importance of Cloud Computing. When organisations do not work in the cloud, most digital technologies cannot be applied. Hereafter, the research shows that RPA and AI are the most promising technologies which are highly applicable in purchasing and contract management activities of public organisations. Research shows that organisations should experiment with RPA first, before applying AI which is a more advanced digital technology.

First, this paper determines the differences between a public and private organisation followed by the research model that assesses the application of digital technologies. This thesis will focus on the entire purchasing process, which includes both purchasing and contract management. Within the literature review, several methods for digitalisation in public purchasing are examined. Subsequently, the methodology of this study is described in chapter 3. Hereafter, in chapter 4 the results are presented. Finally, the key findings, academic and practical contributions, limitations, and future research are presented in chapter 5.

2 Theoretical framework: digital technologies will impact the original purchasing process

2.1 Public procurement needs, compared to private procurement, to consider multiple rules and regulations

Digital technologies are already often applied in the purchasing department of private organisations. To answer the question whether these technologies can contribute to public purchasing, the differences between private and public purchasing needs to be determined.

Public procurement differs from private procurement (Vaidya, Sajeev, & Callender, 2006, p. 76). Telgen, Harland, and Knight (2012) state that "when comparing public and private sector procurement it appears that the demands on public procurement are greater and more highly varied than those on private sector procurement" (p. 17).

The goal of public purchasing is, compared to private purchasing, more than just achieving profit (Erridge, 2007, p. 1028; Murray, 1999, p. 35). Private purchasing is mostly focused on achieving the lowest possible prices and reaching the highest profit (Arlbjørn & Freytag, 2012, p. 204). The goal of public procurement includes services like "law and order, health, social services, education, defence, transport and the environment" (Erridge, 2007, p. 1028). Also, public purchasing is more complex and needs to take into account many social and political goals (Vaidya et al., 2006, p. 76). Public organisations have to follow specific rules to make sure that the purchased goods or services are bought at competitive prices (Arlbjørn & Freytag, 2012, p. 204). Within public procurement, it is important to have a "fair and open competition" (Arlbjørn & Freytag, 2012, p. 204). Besides, the objective of public purchasing is to increase competition by including many suppliers, whereas private purchasing tries to minimize the number of suppliers to lower the risks (Vaidya et al., 2006, p. 76).

Public procurement differs from private procurement in terms of both internal and external demands, demands specific to the context, demands to the process and multiple roles (Telgen et al., 2012, p. 17). Concerning external demands, public procurement must be transparent, act with integrity by following the principles, be accountable for the money spent and need to set an example. Besides, concerning internal demands, public procurement needs to serve multiple goals at the same time, of which political goals, and many stakeholders. Also, there are several contextual demands. Public procurement is budget-driven, has an open, but interdependent budget and has culture-specific norms. Subsequently, public procurement has demands on the process, which are following procedures and thresholds, building long-term relationships, and cooperating with other

(public) buyers. Finally, public procurement has multiple roles since it is a significant buyer in the market, a member of the community and must follow rules and regulations (Telgen et al., 2012, p. 17). Table 1 provides an overview of the comparison between public and private organisations.

In conclusion, public and private organisations have a similar basis when doing purchasing activities. However, public organisations have multiple rules and regulations when purchasing. Public procurement needs to be transparent about their activities, act with integrity, be accountable for the money that is spent and set an example. Overall, it could be said that public purchasing is more challenging than private purchasing.

Table 1 Comparison of private and public organisations

	Private organisation	**Public organisation**
Goal of the organisation	Reach the highest profit.	Follow laws and regulations. Be transparent, accountable, set an example, and act with integrity.
Objective regarding suppliers	Minimize the number of suppliers to lower risks.	Increase competition by including many suppliers.

2.2 The Van Weele Purchasing Process Model consists of six phases

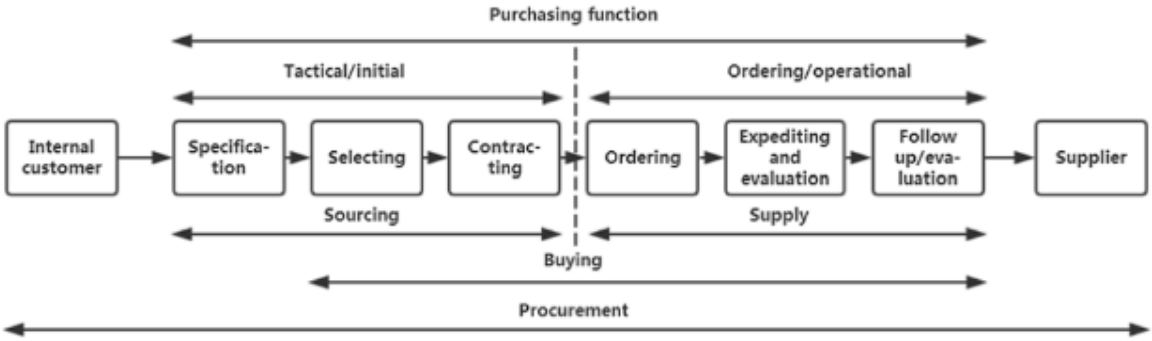
To answer the research question "How can digital technologies be used throughout the purchasing process in a public organisation?" it is important to determine the purchasing process. Procurement (procure-to-pay or purchase-to-pay) is "a process to obtain materials or services in order to support company's operational activities and have an important role in shaping competitive capability of a company" (Dachyar & Praharani, 2016, p. 215). The PMM defines the purchasing process. This model is used to control all purchasing activities (Bäckstrand, Suurmond, van Raaij, & Chen, 2019, p. 1). According to Bäckstrand et al. (2019, p. 3), the early models of the purchasing process are based on decision making. The current PPM are linear (Bäckstrand et al., 2019, p. 3).

The decision-making process shows the purchasing process by following a set of phases, also known as a flowchart (Bäckstrand et al., 2019, p. 3). For example, Rados (1970, p. 12) provides one of these procedures of the buying process for small firms. This model has the goal to describe the definition of purchasing to a group that did not have this responsibility before. Differences in these decision-making models are the places where decisions are

made. For example, decision-making by various people (decision-making units) or the main stakeholders. Another way of using this decision-making process is for make-or-buy decisions (Bäckstrand et al., 2019, p. 4).

Most organisations make use of the linear purchasing process, of which Van Weele's PPM is the most well-known, precise and comprehensive model (Bäckstrand et al., 2019, p. 4; Caldwell, Bakker, & Read, 2012, p. 149). This model divides the purchasing process into six phases, divided into a tactical and an operational part. The tactical part, or strategic sourcing, are all phases until the contract is closed: specification, selecting, and contracting. The operational procurement part starts with the existing contract and consist of ordering, expediting, evaluating, as seen in figure 2 (Bäckstrand et al., 2019, p. 5; Gelderman & Albronda, 2013, p. 34; Schiele, 2019, p. 48). Both parts, strategic sourcing and operational procurement, together is purchasing (Schiele, 2019, p. 47). Schiele (2019) states that "purchasing (or supply management) is the strategic and operative process of supplying an organisation with materials and services from sources external to that organisation; the purchasing department is active in all situations, which require a payment to third parties" (p. 47-48). The phases of the PPM are an important tool to clarify how organizations can best purchase, and at the same time to identify the cause of any problems. Problems can exist in every phase of the PPM, for example having incomplete specifications, or having done a wrong selection of suppliers (Gelderman & Albronda, 2013, p. 34).

Figure 2 Linear PPM of Van Weele (Bäckstrand et al., 2019, p. 4)



The tactical part consists of the first three phases: specification, selecting and contracting. The operational part will take place after the contract is closed. This part consists of the last three phases: ordering, expediting and evaluating, and the follow-up/evaluation.

The first phase is the specification. In this phase, the demands will be identified (Gelderman & Albronda, 2013, p. 34). A tool that can be used in this planning phase, is the

spend cube, which defines who buys, what product, from whom (Schiele, 2019, p. 56). This phase has more complexity in public procurement compared to private, since the specifications of public procurement need to be very detailed and specific (Caldwell et al., 2012, p. 150).

The second phase is supplier selection. In this phase, the purchaser issues a request for quotation (RFQ) from potential suppliers. Based on the quotations, suppliers will be compared and finally selected (Gelderman & Albronda, 2013, p. 37; Schiele, 2019, p. 56). Within public procurement, this phase is influenced by national and international laws and regulations. The European Union (EU) has, for example, set a threshold that describes how the public organisation must tender. When the contract is above a certain threshold, the law describes that the public organisation needs to follow the EU procurement rules and conduct a European Tender. In this case, suppliers from all European countries can take part in a tender. These regulations for public procurement influence the selection phase and makes it more complex since it can create diversity and uncertainty in the market (Caldwell et al., 2012, pp. 151-152).

After suppliers are selected, the negotiations will take place and the contract will be closed in phase three (Gelderman & Albronda, 2013, p. 37). Depending on the use of single, dual or multiple sourcing, which will be chosen in the selection phase, the number of contracts will be determined (Caldwell et al., 2012, p. 152). In this phase, contract management is an important topic. The availability of contracts is an important challenge contract management has. Often, contracts are stored in a decentralised location (Gelderman & Albronda, 2013, p. 39).

The fourth phase, ordering, is the start of the operational part. In this phase, the order will be placed. To avoid misconceptions, there are specific persons in the organisations that have the authority of signing the order (Gelderman & Albronda, 2013, p. 38). In some cases, employees or departments purchase without relying on a contract with a supplier, this is called maverick buying (Gelderman & Albronda, 2013, p. 38; Schiele, 2019, p. 48). Within public procurement, the transparency of the ordering process is crucial (Caldwell et al., 2012, p. 155; Telgen et al., 2012, p. 17). Public procurement needs to be accountable for the purchased goods and must be able to give well-substantiated explanations (Telgen et al., 2012, p. 17).

When the order is placed, the phase of expediting and evaluation take place. In this phase, delivery times, quantities, certificates and documents are checked (Gelderman & Albronda, 2013, p. 39). Expediting is a combination with the evaluation of suppliers since the delivery

and performance highly depend on each other. An important issue is linking the performance of a supplier to bonuses or penalties (Caldwell et al., 2012, pp. 155-156).

After the delivery is done, the last phase, follow up/evaluation, takes place (Gelderman & Albronda, 2013, p. 39). In this last phase, the supplier will be evaluated on its performance (Schiele, 2019, p. 58). This is done to improve the performance of the supplier. An often-used method is the "check" of the plan, do, check, act model (Caldwell et al., 2012, pp. 155-156). There are two different steps of supplier evaluation: quantitative and qualitative. Quantitative supplier evaluations are based on data regarding the delivery, the quality, and the number of returns. The qualitative supplier evaluations investigate the reasons behind problems. In this phase, both buyer and supplier fill in a questionnaire which will be discussed afterwards (Schiele, 2019, p. 58). When necessary, potential problems will be discussed with the supplier (Gelderman & Albronda, 2013, p. 40).

In conclusion, the entire PPM consists of six phases: specification, selecting, contracting, ordering, expediting, and evaluating. Overall, the process is similar in both public and private purchasing. However, within public procurement, especially the first two phases are more complex, which is different compared to private procurement.

2.3 Technologies within the four industrial revolutions

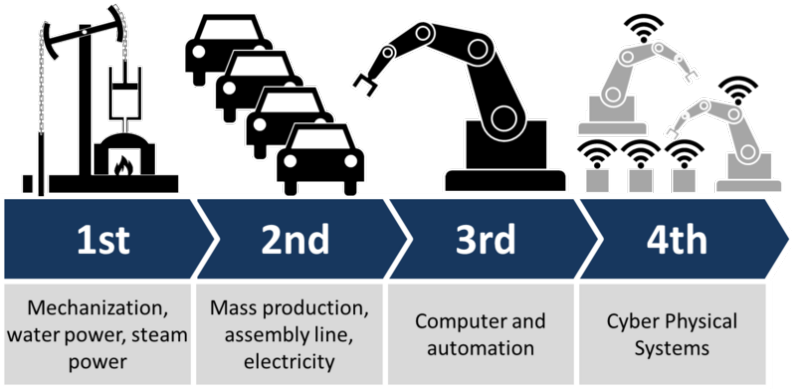
Every industrial revolution describes a period in which an important change or development took place. This change must have an economic and societal impact (Schiele, Bos-Nehles, Delke, Stegmaier, & Torn, 2021, p. 2). Since the third industrial revolution, digitalisation is a growing topic (Schiele & Torn, 2019, p. 508). In the beginning, digital methods were only used as support. Nowadays, digitalisation is used in different forms throughout the entire business process (El Sawy, Malhotra, Park, & Pavlou, 2010, p. 836; Schiele & Torn, 2019, p. 508). It could be stated that different types of technologies are likely to shape an industrial revolution. In the following chapter, a description of all four industrial revolutions is given. Subsequently, because the third and fourth industrial revolutions are critical in the concept of digitalisation, a more detailed explanation is given.

2.3.1 It is necessary to understand all four industrial revolutions to understand the potential impact of industry 4.0

To better understand the potential impact of the fourth industrial revolution, or industry 4.0 (I4.0), this section will provide a short description of all industrial revolutions. An industrial revolution is described as "a period in which the development of machinery leads

to major changes in agriculture, industry, transportation, and social conditions" (Cambridge Dictionary, n.d.). Industrial revolutions "are technology-induced but lead to and require fundamental economic and societal changes" (Schiele et al., 2021, p. 2). Authors disagree about the number of industrial revolutions. Most authors state that there are four industrial revolutions (Schiele et al., 2021; Schiele & Torn, 2019; Torn, Pulles, & Schiele, 2018; Xu, David, & Kim, 2018), while other authors describe three industrial revolutions (Janicke & Jacob, 2013) or even five industrial revolutions (Perez, 2010). Within this thesis, the number of four industrial revolutions will be followed. Figure 3 provides a short overview of the four industrial revolutions.

Figure 3 Four industrial revolutions (Hwang, 2016, p. 10)



The first industrial revolution began around 1760 (Greenwood, 1999, p. 4; Xu et al., 2018, p. 90). Schiereck (2021) describes that this first industrial revolution is known for "replacing human abilities with machine tools, substituting human and animal power with power from machines (steam engines) and easier access to and processing of natural resources, specifically in chemical and metal related fields" (p. 7). An important step in this first industrial revolution was the invention of the steam engine and the efficient use of waterpower. The invention of both generators made new manufacturing processes possible and resulted in factory systems (Xu et al., 2018, p. 90; Zijm, 2019, p. 76). As a result of this invention, many people stopped working on the farms and moved to the city (Xu et al., 2018, p. 90).

The second industrial revolution started around 1860, with the invention of "electricity and electrical motors" (Torn et al., 2018, p. 3). This electronification led to the introduction of "electrically-powered mass production, creating steel industry, and telegraph and railroad systems" (Hwang, 2016, p. 10). A major step in this industrial revolution, is the availability of the first assembly line (Schuh, Potente, Varandani, Hausberg, & Fränken, 2014, p. 3; Torn

et al., 2018, p. 3; Xu et al., 2018, p. 90). Ford factories was the first to introduce this assembly line, used for the manufacturing of automobiles. Never before, had a machine been able to produce at this rapid speed (Zijm, 2019, p. 76). Besides the ability of mass production, this industrial revolution is also known for the division of labour. The division of labour made it possible to split work tasks. In this way, tasks are simplified and instead of one employee doing the entire process, each employee would perform a part (Schiereck, 2021, p. 8).

The third industrial revolution began around 1950 and described the change from analogue to digital technology (Schuh et al., 2014, p. 3). The third industrial revolution (or Industry 3.0) is "an era of rapid technological progress associated with the development of information technologies" (Greenwood, 1999, p. 2). This revolution is known for robotisation and digitalisation (Schiele et al., 2021, p. 2), with the use of computers and automation within manufacturing (Torn et al., 2018, p. 3). Since this revolution, more large firms started using computers and data (Khan, 1987, p. 115). A driver from the third industrial revolution was the invention of transistors. This revolution "has offered phenomenal applications of computers and electronic gadgets since the 1970s" (Hwang, 2016, p. 10).

Currently, the fourth industrial revolution is building on the third industrial revolution (Xu et al., 2018). This industrial revolution describes the "smart industries". This industrial revolution, also called Industry 4.0, started in Germany with the federal government's technological strategy (Hwang, 2016, p. 10). Industry 4.0 "will leverage the internet, digital technologies and quantum sciences to drive further into autonomous, intelligent cyber-physical systems" (Hwang, 2016, p. 10). According to Schiele et al. (2021), Industry 4.0 distinguishes itself by including "cyber-physical systems characterized by autonomy and machine-to-machine communication" compared to the digitalisation and robotisation of the third industrial revolution (p. 2).

Within this topic, the third and fourth revolutions are considered most important and are therefore explained more in detail in the next chapter.

2.3.2 Digitalisation and automation in the third industrial revolution

After the invention of electricity as a driver for mass production and the use of assembly lines within production, the third industrial revolution builds on the second (Torn, 2017, p. 18). With the use of "electronics and Information Technology (IT)" factories were able to automate the production (Prisecaru, 2016, p. 61; Torn, 2017, p. 18).

The third industrial revolution is known for its shift from analogue to digital technology and is therefore also called the ‘digital revolution’ (Schuh et al., 2014, p. 4). This industrial revolution started around 1974 when the price of oil dropped (Greenwood, 1999, pp. 2-3). Greenwood (1999, p. 2) defines this digital revolution that started at the information age, as an era of technological development. Schuh et al. (2014) state that “one technological driver behind the third industrial revolution is the invention of integrated circuits that allow to increase computational power and decrease costs continuously and in an exponential manner” (p. 4). This invention made the use of information technology able in different industries (Schuh et al., 2014, p. 4). The main technical achievements of the third industrial revolution are the invention of computers and robots (Prisecaru, 2016, p. 57).

According to Schiele, the third industrial revolution is known for the human-machine interface, digitalisation and automation (Schiele, 2016, p. 15; Torn et al., 2018, p. 5). Digital systems were an important topic in the third industrial revolution. An example in purchasing is the use of an electronic catalogue, which still required a human employee. Also, automated systems were introduced in the third industrial revolution. Equal to the digital systems, these automated systems required a human employee to set a pre-defined plan. The system is not able to make reactions by itself. Finally, the human-machine interface required humans to assist the machines (Torn et al., 2018, p. 5).

2.3.3 The shift from Industry 3.0 to Industry 4.0

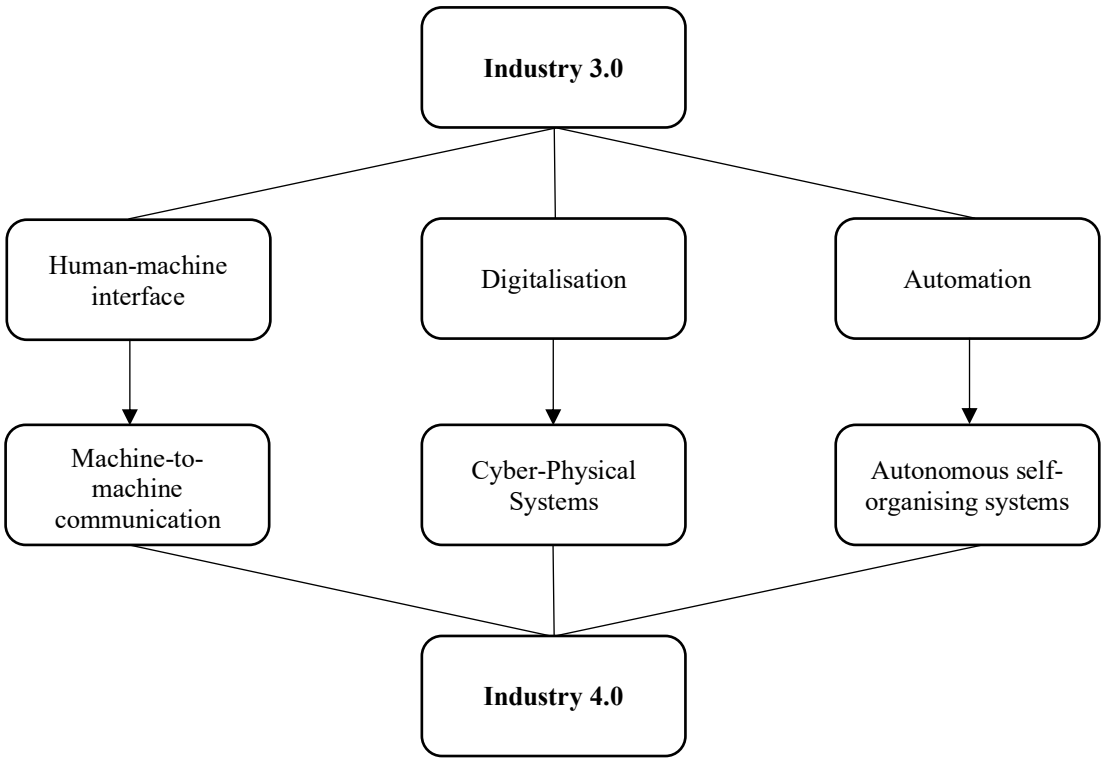
Technologies of industry 4.0 are built upon their predecessors of industry 3.0. The human-machine interface of industry 3.0 evolved to machine-to-machine communication in industry 4.0. Machines were able to communicate with each other without any human necessary in the process (Schiele, 2016, p. 16).

Besides, digitalisation shifted to cyber-physical systems, systems able to make decisions independently (RMIT University Australia, n.d.). However, cyber-physical systems are used within production industries (Schiele et al., 2021, p. 2). In the third industrial revolution, these systems were digital. Compared to the fourth industrial revolution, these are not connected to the physical world (Torn et al., 2018, p. 5).

Finally, automation evolved to autonomous self-organising systems. Within this topic of Industry 4.0, new technologies and applications were developed (Schiele, 2016, p. 16). Within Industry 3.0, the automated systems required external help, while in Industry 4.0, the autonomous self-organising systems are able to react independently and make decisions by themself (Torn et al., 2018, p. 5).

In conclusion, the applications of Industry 3.0, required a human to make decisions and to define a plan the machine needed to follow. Nowadays, in Industry 4.0, the systems can make their own decisions and reactions. An overview of the transition of Industry 3.0 to Industry 4.0 is given in figure 4.

Figure 4 From Industry 3.0 to Industry 4.0



2.3.4 The use of Cyber-Physical Systems and machine-to-machine communication in the fourth industrial revolution

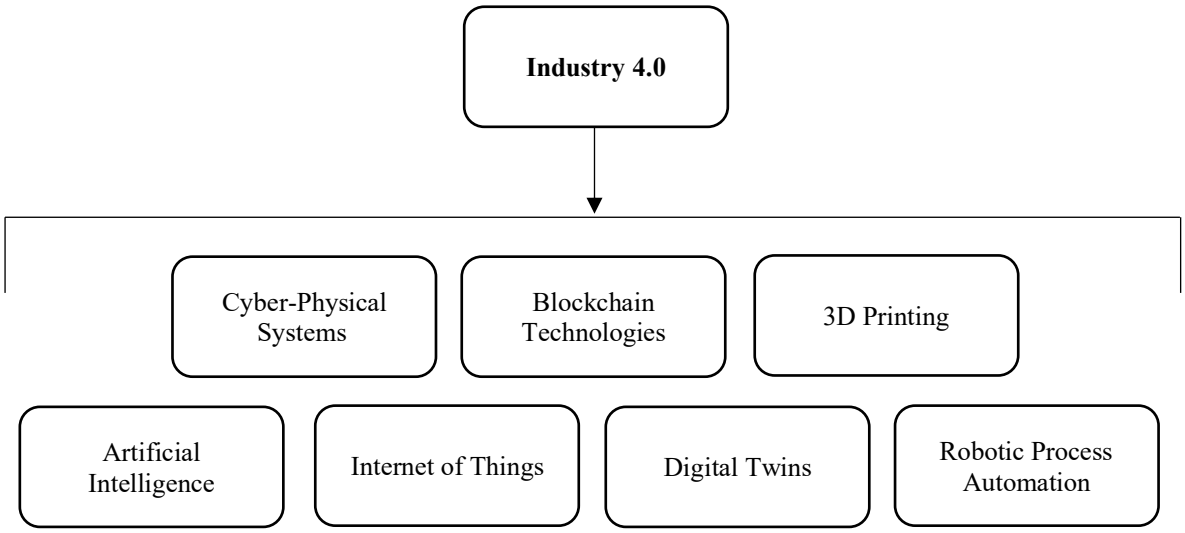
After the third industrial revolution, which included automation and digitalisation, new technological developments started the fourth industrial revolution, or Industry 4.0 (Schiele et al., 2021, p. 2). Industry 4.0 is "the merging of the physical and digital worlds by means of cyber-physical systems and autonomous machine-to-machine communication" (Schiele et al., 2021, p. 1; Schiele & Torn, 2019, p. 508). This revolution is "characterised by a fusion of technologies that is blurring the line between the physical, digital and biological spheres" (Schwab, 2015).

According to Xu et al. (2018), Industry 4.0 will have "1) lower barriers between inventors and markets, 2) more active role for the artificial intelligence (AI), 3) integration of different technics and domains (fusion), 4) improved quality of our lives (robotics) and 5)

the connected life (Internet)" (p. 91). The topic of Industry 4.0 is developed by its new digital technologies that affect manufacturing (Xu et al., 2018, p. 91).

Several technologies shape Industry 4.0 and might lead to incremental changes in businesses (Schiele et al., 2021, p. 3). However, even though Industry 4.0 is growing in importance, firms often lack knowledge about how it could be used in business. These technologies are Cyber-Physical Systems, Blockchain Technologies, Digital Twins, 3D printing, Artificial Intelligence, Internet of Things, and Robotic Process Automation (Kumar et al., 2021, p. 1; Salkin, Oner, Ustundag, & Cevikcan, 2017, p. 3; Schiele et al., 2021, p. 4; Schiereck, 2021, p. 12; Wang & Wang, 2016, p. 1). In figure 5 underneath, an overview of the technologies of Industry 4.0 is given.

Figure 5 Technologies of Industry 4.0



First, Internet of Things (IoT) is an important technology of industry 4.0. IoT is "a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies" (International Telecommunication Union, 2012; Kumar et al., 2021, p. 3). IoT can connect "devices, systems, and services that goes beyond machine-to-machine communications and covers a variety of protocols, domains, and applications" (Xu et al., 2018, p. 92). The IoT device can discover events with the use of sensors. The information that is collected is analysed and interpreted. Relevant information from this analysis is shared with the user. With the use of IoT, machines can better communicate with other machines, as well as with the user (Kumar et al., 2021, p. 3). IoT can serve as a basis for many technologies of Industry 4.0, such as Cyber-Physical Systems (Schiereck, 2021, p.

17). In purchasing, IoT can be used to gain insights in for example the spend analysis and buying patterns of customers. By having these insights, an organisation can make accurate estimations and make better decisions. It could lead to cost savings and increased value to the purchasing process (Goyal, 2018).

Second, Robotic Process Automation (RPA) is an example of automatic machine-to-machine interaction in Industry 4.0. According to (Xu et al., 2018, p. 92), robotics are likely to change our daily lives. RPA is software that automates tasks. It imitates the interaction of a human through a software system (Syed et al., 2020, p. 1). According to Syed et al. (2020) "The tasks that bots perform are typically rule-based, well-structured, and repetitive" (p. 1). Such as the transferring of data, automated e-mail response, and collecting data about salary from various sources (Syed et al., 2020, p. 1). Robots can improve activities in different environments. At work, the use of robots will ultimately "create new jobs, improve the quality of existing jobs, and give people more time to focus on what they want to do" (Xu et al., 2018, p. 92). According to Syed et al. (2020), the use of RPA could lead to several opportunities within businesses. RPA can reduce costs, prevent errors, increase productivity and reliability. This digital technology can perform repetitive processes with high volumes for long times, is flexible but dependent on software updates (pp. 3-8).

Third, Cyber-Physical Systems (CPS) are likely to shape industry 4.0 according to Schiele et al. (2021, p. 4). CPS connect the physical with the digital world. Lee, Bagheri, and Kao (2015) define CPS as "transformative technologies for managing interconnected systems between its physical assets and computational capabilities" (p. 18). These systems "are feedback systems that detect and analyse changes in the environment based on data retrieved from sensors, with the aim of making autonomous decisions that impact entities in the real world" (Schiele et al., 2021, p. 4). The high volume of data that is collected from these sensors is known as Big Data (Lee et al., 2015, p. 18). CPS are often used within production industries (Schiele et al., 2021, p. 2). A CPS combines technologies into "new usages and services with near endless possibilities" (Schiereck, 2021, p. 14).

Subsequently, digital twins "are computer-aided design models that represent accurate copies of physical entities in real-time" (Schiele et al., 2021, p. 4). This virtual model gives an organisation of insight into the consequence of a decision or change. By providing information about the consequence of a decision, an organisation can reach cost savings (Schiele et al., 2021, p. 4).

Also, blockchain is an important technology, part of industry 4.0 (Schiele et al., 2021, p. 4). Blockchain "is a distributed database comparable to an electronic ledger that can hold

any type of information" (Schiele et al., 2021, p. 4). As the word says, blockchain is chained blocks with information that continuously grow (Schiele et al., 2021, p. 4). The "block" describes the transactions and the "chain" describes the links between the blocks (Kumar et al., 2021, p. 5). Blockchain is an administrative tool that simplifies and fastens the communication between human and machine (NEVI, 2018, p. 1). Blockchain is used by saving many copies of data on many independent computers in the network. In this way, data will be better secured, for example against hacking. It has the ability to "improve process efficiencies by cutting down the time and procedural formalities required for a transaction, while enabling the secure transfer of data and value" (Kumar et al., 2021, p. 5). Opportunities of blockchain lie within the supply chain, logistic management, organisations with high data processing (such as banks and insurance companies), and public organisations. Blockchain provides higher reliability, faster processing and fewer mistakes (NEVI, 2018, p. 1).

Subsequently, according to Schiele et al. (2021, p. 4), three-dimensional printing (3D printing) is also a technology that is likely to shape Industry 4.0. Recently, 3D printing has grown in importance (Schiele et al., 2021, p. 4). The use of 3D printing could reduce barriers between the producer and the market. 3D printing will enable entrepreneurs to start a small business and produce products more easily. The production of prototypes is easier and faster, and therefore costs are decreased compared to traditional methods (Xu et al., 2018, p. 92).

Lastly, Schiele et al. (2021, p. 4) describe that AI is likely to shape Industry 4.0. AI is considered as a base technology for Industry 4.0. Even though AI is not new, it does belong to Industry 4.0 (Schiereck, 2021, p. 14). Recently, AI has become more promising due to the rising availability of data and processing capacity. AI needs a big amount of data to improve the decision-making and planning of processes (Schiele et al., 2021, p. 4).

AI is considered to be the most promising technology of Industry 4.0. Therefore, a more detailed explanation of this technology follows in the next paragraph.

2.4 Artificial Intelligence is the thinking and decision-making of machines

The history of Artificial Intelligence dates back to 1950 when English scientist Alan Turing published an article called Computing Machinery and Intelligence. This article addresses the question of whether machines can think (Turing, 1950, p. 67). This question is still used and is called, the Turing test. Not much later, the concept of Artificial Intelligence was born. However, in the 1970s the British government stopped funding AI research, and thus, the so-called "AI winter" started (Haenlein & Kaplan, 2019, p. 3; Sun & Medaglia, 2019, p. 2). Nevertheless, in the 21st century more investments were done, and developments were made, which resulted in a sudden growth of the innovation of AI (Lewis, 2014). Major steps in the innovation of AI took place in 1997 and 2011. In 1997, the first IBM computer was able to beat the world champion in a chess game, and in 2011 the computer was able to beat the champions in the game Jeopardy (IBM, n.d.). Also, in 2016 the Artificial Intelligent system of Google, AlphaGo, won the game Go from the world champion. Go is even more complicated than Chess, by having a huge number of optional moves (Chen, 2016, pp. 5-6). These important events show that the software was able to use natural language, human and machine were able to interact with each other (IBM, n.d.).

2.4.1 The definition of Artificial Intelligence

AI is the most important topic of this research. The research is focused on the use of AI within purchasing and contract management of public organisations. Literature gives several definitions or interpretations of AI. A short overview of the definitions is given in table 2.

Table 2 Definition of Artificial Intelligence

The Engineering and Physical Sciences Research Council	"Technologies aim to reproduce or surpass abilities (in computational systems) that would require 'intelligence' if humans were to perform them. These include: learning and adaptation; sensory understanding and interaction; reasoning and planning; optimisation of procedures and parameters; autonomy; creativity; and extracting knowledge and predictions from large, diverse digital data".
Haenlein and Kaplan (2019)	"A system's ability to interpret external data correctly, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation" (p. 10)
Keswani (2013)	"The capability of a device to perform activities, which would otherwise only be expected of the human brain. These activities include the capacity for knowledge and the ability to acquire it. It also comprises of the ability to judge, understand relationships and last but not least produce original thoughts" (p. 348).

The Association for the Advancement of Artificial Intelligence (AAAI)	"The science and engineering of making intelligent machines, especially intelligent computer programs" (van Ooijen, 2019, p. 248).

All definitions describe Artificial Intelligence as a system, device, technology, or machine. As the word 'intelligence' also describes, all definitions state that this system, device, technology, or machine, requires knowledge to perform activities that were otherwise done by a human. the definitions of The Engineering and Physical Sciences Research Council (n.d.), Haenlein and Kaplan (2019), and Keswani (2013) agree that this knowledge (the data) makes the system able to react, adapt, interpret and learn. Only the definition of the Advancement of Artificial Intelligence (AAAI) (van Ooijen, 2019, p. 248), does not describe the knowledge of the machine. Besides, only the definition of Haenlein and Kaplan (2019) is about the use of 'external' data, while this is not mentioned in the other definitions.

Alternative to the general definition of AI, Russell and Norvig (2002) describe AI in four categories. "These are: (1) systems that think like humans, (2) systems that act like humans, (3) systems that think rationally, and (4) systems that act rationally" (Loureiro, Guerreiro, & Tussyadiah, 2020, p. 1). According to Loureiro et al. (2020), AI systems need to have natural language processing, knowledge representation, automated reasoning, and machine learning. Yet, no concrete definition of AI has been developed. However, this has not hindered the innovation of AI (Loureiro et al., 2020).

It can be concluded that AI is a system, machine, device or technology that has the intelligence, which is collected from many data, to perform activities that were originally done by humans. Within this research, the definition of Haenlein and Kaplan (2019) will be used, who define AI as: "a system's ability to interpret external data correctly, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation" (p. 10).

2.4.2 *The subsets of Artificial Intelligence*

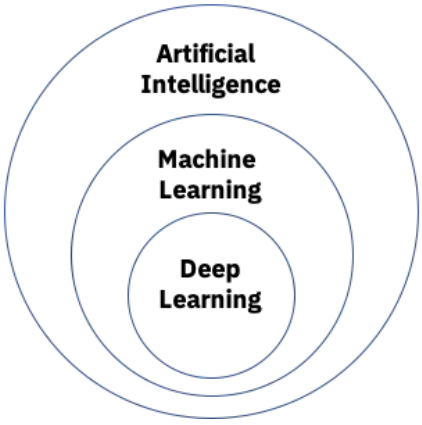
AI can be determined as a machine that can imitate human functions like learning and problem-solving (Ongsulee, 2017). An AI system has a wide interpretation. It can consist of a problem-solving system, able to make its own decisions based on complex rules or a system that can develop intelligence or human emotions (IBM, 2020). AI has two subsets: machine learning and deep learning as seen in figure 6.

According to Arthur Samuel, machine learning is a subset of AI that gives “computers the ability to learn without being explicitly programmed” (Ongsulee, 2017, p. 2). Machine learning is a system that allows computers to use data to learn by itself and make predictions (Balyen & Peto, 2019; Ongsulee, 2017). It “allows algorithms to make predictions and solve problems based on large amounts of data, without being explicitly programmed” (Murphy et al., 2021, p. 2).

Based on machine learning, systems can process data based on business rules, this is called deep learning (Talhaoui & Mulder, 2019, p. 4). Deep learning is can be considered as a subset of machine learning that uses artificial neural networks (ANN) (Balyen & Peto, 2019). Deep learning “goes further to use multiple layers of ANN to solve complex problems from unstructured data, much like the human brain” (Murphy et al., 2021, p. 2). Compared to machine learning, deep learning has more than one hidden layer. Deep learning can achieve tasks that machine learning models are unable to (Oppermann, 2019).

The difference between deep and machine learning can be shown by Apple’s Siri and Netflix. Netflix is an example of machine learning, a system that requires a lot of data to train the system before it can be used. This system is self-learning, based on someone’s profile, new requirements for films and series are given (Talhaoui & Mulder, 2019, p. 8). On the other hand, Apple’s Siri is an example of deep learning, which has voice recognition without training. Apple’s Siri recognises patterns and makes suggestions based on these patterns. This is a complex system that is able to react even quicker and more correct than humans (IBM, 2020).

Figure 6 Artificial Intelligence vs. Machine Learning vs. Deep Learning (IBM, 2020)



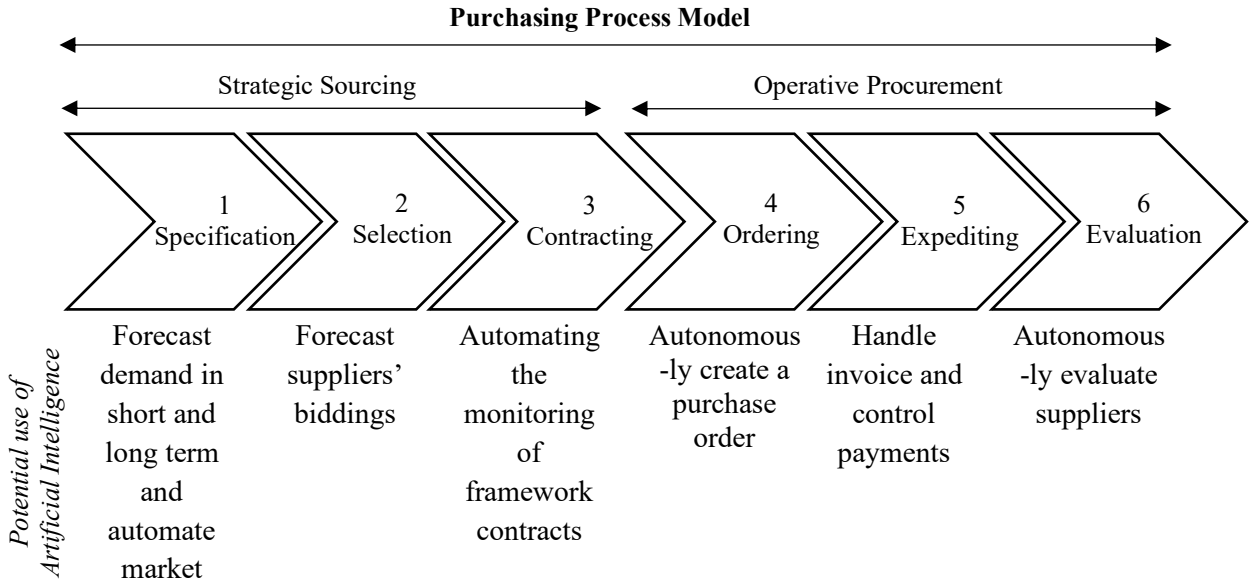
The figure above describes that deep learning could be seen as a subset of Machine Learning. Also, Machine Learning is a subset of Artificial Intelligence. In conclusion, Artificial Intelligence is the overarching topic.

2.5 Artificial Intelligence can be applied in all phases of the purchasing process

Within the several rising digital technologies, AI is very important. Therefore, to answer the research question, it is important to determine how AI can be used within the phases of the PPM.

In the first phase, the specification phase, ANN can forecast the demand in the short and long term (Efendigil, Önüt, & Kahraman, 2009, p. 6698). Besides, AI is able to automate market research, providing opportunities and challenges (Allal-Chérif, Simón-Moya, & Ballester, 2021, p. 75). Subsequently, in the selecting phase, AI can forecast suppliers' biddings in the negotiations, which led to a decrease in selection and negotiation times, costs, and efficiency (Ocampo, Abad, Cabusas, Padon, & Sevilla, 2018, p. 36). Moreover, in the contracting phase, AI can also improve the efficiency of contract management, by analysing contracts (Allal-Chérif et al., 2021, p. 75) and automating the monitoring of framework contracts (Toorajipour, Sohrabpour, Nazarpour, Oghazi, & Fischl, 2021, p. 505). In the fourth phase, ordering, AI could be able to autonomously create a purchase order (Min, 2010, p. 22). In the fifth phase, expediting and evaluating, AI can handle invoices and control payments (Allal-Chérif et al., 2021, p. 75). Finally, in the last phase, the follow-up/evaluation, AI can evaluate suppliers by taking into account multiple factors (Min, 2010, p. 17).

Figure 7 Potential use of Artificial Intelligence in the PPM



The use of AI in the PPM is getting more attractive to organisations. The Deloitte CPO survey of 2016 investigated the technology areas that are most likely to receive investments in that coming year. This concerns buying software and services to improve the purchasing organisation and the infrastructure. As mentioned in the introduction, many organisations have already made investments in the use of technology (e.g., AI) for spend analysis. This also has the highest priority according to the CPO's. Another important subject on which big improvements can be made by investments in technology is contract management. The advantage of contract management on a globally operating business is that the contract is only in one location since these are most often on paper. A big challenge of contract management is to put this contract in an online database with a good structure, to make it globally available. Also, e-sourcing is an important technological improvement in purchasing where AI can be used. E-sourcing can be used in the entire PPM, from the RFQ until having the contract (Umbenhauer & Gregson, 2016, p. 15).

3 Methodology: a qualitative method is used to conduct the research

3.1 The qualitative research approach is used to produce in-depth information

Within this research, a qualitative research approach is used to gain insight into the opportunities digitalisation can have in public organisations (Verhoeven, 2016, p. 31). This research approach is a well-considered research strategy since no research is conducted on the topic related to the research question. Qualitative research is therefore recognised to be a suitable approach for researching a topic of which little is known (Denscombe, 2012; Patten & Newhart, 2017). Queirós, Faria, and Almeida (2017) describe that the goal of qualitative research "is to produce in-depth and illustrative information in order to understand the various dimensions of the problem under analysis" (p. 370). In addition, this means that this research has an inductive approach "that allow answering "how" and "why" questions and detecting organizational processes over time" (Woiceshyn & Daellenbach, 2018, p. 184).

Based on the insights from a good mix of respondents, this research provides information about digitalising public purchasing and contract management. Therefore, it is essential to interview respondents with relevant knowledge about the subject to collect in-depth information and new insights (Verhoeven, 2016, p. 32). In conclusion, a qualitative research approach was used to gain an understanding of the respondents' knowledge and experience to identify the opportunities digitalisation has within the purchasing of public organisations (Queirós et al., 2017, p. 370).

3.2 Based on theoretical considerations two research units are selected

To answer the research question, research units are selected. According to Baarda (2014), research units are the persons, authorities, or situations about which you want to make statements based on your research (p. 25). Since the population is large, a representative sample is selected.

Within qualitative research, saturation is important. This requires a researcher to continue to collect data until there is no more new information (Baarda, 2014). However, due to the time of the graduation period, this is not feasible, and 16 interviews are conducted. Because saturation is not possible, a heterogeneous group of respondents is selected.

For this research, purposive sampling is used. The choice of unit is made based on theoretical considerations. Interviews will take place with two different research units: (1) experts in the field of digitalisation, public organisations, and/or purchasing and (2) public organisations that use a form of digitalisation in purchasing.

To get more information about the trends, developments, and innovations of digitalisation in public purchasing, experts are selected as the first research unit. The group of experts are selected by conducting desk research. A list of these interviewees is presented in table 3.

Additionally, to get more information about the applications in practice, employees from public organisations that have applied digital technologies in purchasing are selected as the second research unit. To select these research units, experts are questioned and desk research is conducted. Table 4 provides an overview of the respondents from public organisations.

Within both tables, the interviewees are placed in order of relevance to the research. This is determined by the level of purchasing categories and digital solutions touched upon by the interviewee. Some interviewees had specialised knowledge in one area, while others had broad knowledge in multiple areas.

Table 3 Interviews with experts

Specialised in one area ---------- Multiple areas

#	Interviewee role	Duration	Organisation
1	Managing Partner	1h 43m	Qando
8	Co-Owner	1h 47m	Omnifocus
5	Partner	1h	Significant Group
6	Country Manager	58m	Mercell (formerly Negometrix)
9	Co-Owner	1h 12m	E-proQure/Omnifocus
4	Founder & Owner	49m	Sourcing Champions
3	Managing Partner	52m	GRIPPR
10	Client Relationship Executive for Central Government	57m	IBM
7	Customer Success Manager	47m	ProActive

Table 4 Interviews with other public organisations

Specialised in one area ---------- Multiple areas

#	Interviewee role	Duration	Organisation
2	Directeur	53m	UBR HIS
16	Coordinating Director Purchasing	47m	Ministerie van Justitie en Veiligheid
15	Project Manager RPA	42m	Shared Service Center Dienst Jutitiële Instellingen
14	Senior Purchasing Advisor (a.i.)	50m	Hogeschool Saxion
12	Strategic Purchasing Advisor	46m	Gemeente Hengelo
13	IT Contract Manager	47m	Nederlandse Spoorwegen
11	Contract Manager	47m	UBR HIS

3.3 A semi-structured oral form for data collection

There are several ways to make choices on how to conduct the research. According to Baarda (2014), the form, means of communication, person and points of interest have to be defined.

Data is collected using semi-structured, in-depth interviews (Jamshed, 2014, p. 87). “The semi-structured interview is an exploratory interview” (Magaldi & Berler, 2020, p. 1) This method is used for open interviews, which are half or entirely not structured. Due to COVID-19, the researcher was unable to conduct face-to-face interviews. Therefore, the means of communication that is used to conduct the interviews is video conferencing.

The research has an individual approach. A semi-structured interview uses both structured- and open questions. Therefore, not only a topic list is used, nor entirely structured questions (Verhoeven, 2016). With the use of semi-structured interviews, there is more flexibility for new inputs from the interviewee. As a result, new insights can be attained (Verhoeven, 2016). The interviews are performed by following the structure of the interview guide. The interview guide is composed with the use of the theoretical framework. The interview guide is made for both research units and is presented in appendix I.

3.4 Analysing data with the use of ATLAS.ti

After the data is collected, the results have been analysed. Analysing data in qualitative research is difficult since the result it is often not known before (Baarda, 2014). Since all data was collected by verbal communication, the interviews were recorded, and the data was transcribed to maintain all the gathered information. These transcripts were reviewed several times to increase understanding of the data and increase the researcher’s transparency.

After reviewing the transcripts, the next step for a deeper analysis was to code the transcripts. In this step, statements are coded, quotations selected, and codes grouped. With the use of coding, the raw data is structured into a schema. This schema allows finding patterns in all data. The program that is used to do this deeper analysis, is ATLAS.ti. “ATLAS.ti is a workbench for the qualitative analysis of large bodies of textual, graphical, audio and video data” (ATLAS.ti, n.d.).

Within this research, a thematic analysis method is used to analyse the qualitative dataset. This method is used for “systematically identifying, organizing, and offering insights into patterns of meaning (themes) across a data set” (Braun & Clarke, 2012, p. 57). The data is analysed according to the four phases outlined by Verhoeven (2011):

1. The exploration phase: transcribe and investigate the gathered information.
2. The specification phase: define and divide codes into groups.
3. The reduction phase: identify patterns and formulate themes.
4. The integration phase: integrate the analysed concepts into a table to evaluate the structure.

4 Results

This research is focused on the applicability of digital technologies in public purchasing. As mentioned in the theoretical framework, there are differences between public and private organisations. These differences mostly arise from laws and regulations. Since public organisations are the unit of analysis in this research, appendix II provides more information on why public organisations are special. Hereafter, appendix III describes purchasing in a public organisation.

In this chapter, the results are described. As mentioned, purchasing has an administrative function that makes it suitable to digitalise. First, the interest in digitalising public purchasing is described. Subsequently, the digital technologies are described that can be applied in public purchasing. Finally, the application of these methods for digitalisation is described for each phase of the PPM from Van Weele.

4.1 Digitalisation will lead to several changes in the purchasing department of a public organisation

Digitalisation is the automation of optimised processes and can provide additional management information (I. 9). According to most interviewees, choices regarding digitalisation need to be made based on the information and process efficiency (I. 3, 5, 6, 8, 9, 13, 14). According to interviewee 8, the bigger questions are: “what information is needed?” and “how efficient is the organisation working?”.

To digitalise the purchasing department, an organisation first needs to formulate the current and desired processes, bottlenecks and possible solutions, and then assess which type of technology is best applicable (I. 3, 9, 13). It needs to be understood how technologies can contribute to the most professional purchasing possible (I. 13, 16). Therefore, decisions need to be based on the wishes of the end-user (I. 6, 15). In public organisations, this is the employee or the civilian. Also, organisations need to be aware that a digital transformation takes time (I. 1, 4, 5). An organisation needs to make small improvements step-by-step and expand over time (I. 1, 3, 4, 5, 8, 9, 13). Examining key issues for the coming years can help an organisation to determine how digital technologies can be applied (I. 5, 8). To start, it is important to review topics that can be automated easily (I. 3, 14). For example, anything that requires retyping must be digitalised (I. 3, 5).

Digital technologies are a tool to improve processes (I. 4, 13). To use digitalisation within certain processes, the process sometimes needs to be adjusted (I. 11, 12). According to interviewee 5, public organisations must not hold on to old processes and tools. Where

possible, repetitive administrative tasks must be automated (I. 5, 13, 15). Also, digitalisation can help to evaluate key performance indicators (KPI's) for topics such as delivery times or service (I. 6, 9). In this way, an organisation can control its supplier easier with fewer resources (I. 9). Within public purchasing, digitalisation has a lot to offer.

Organisations must have the capacity to change to a digital environment (I. 6, 9). Practice shows that less digitally skilled managers apply less software within the organisation (I. 1). Also, according to interviewee 9, the behaviour of people is often the most important hick-up in digitalisation. Digitally unskilled employees often go back to the use of e-mail and other tools (I. 9). Therefore, the use of digital systems should be veneered in a top-down approach (I. 4). However, it is important that employees are included in the entire digitalisation process (I. 6, 9). Employees need time to become familiar with it (I. 13, 16). Therefore, organisations should start small, but think big (I. 8, 13, 14).

No evidence shows that digitalisation will reduce the number of jobs in an organisation (I. 10). In practice, digital technologies can be used in operational activities to replace administrative tasks that employees consider to be boring (I. 2, 4, 10). Nowadays, tasks and responsibilities of purchasers increase (I. 1). However, the same number of employees is expected to perform more work (I. 1). With the use of digital technologies, employees will have more time to focus on these new topics and other tasks that require more knowledge (I. 10, 11, 13). For example, tasks such as retrieving data, finding new suppliers and developments, and consolidating suppliers (I. 1, 13). Besides, the digitalisation of administrative tasks reduces the possibility of making mistakes (I. 2, 4, 8).

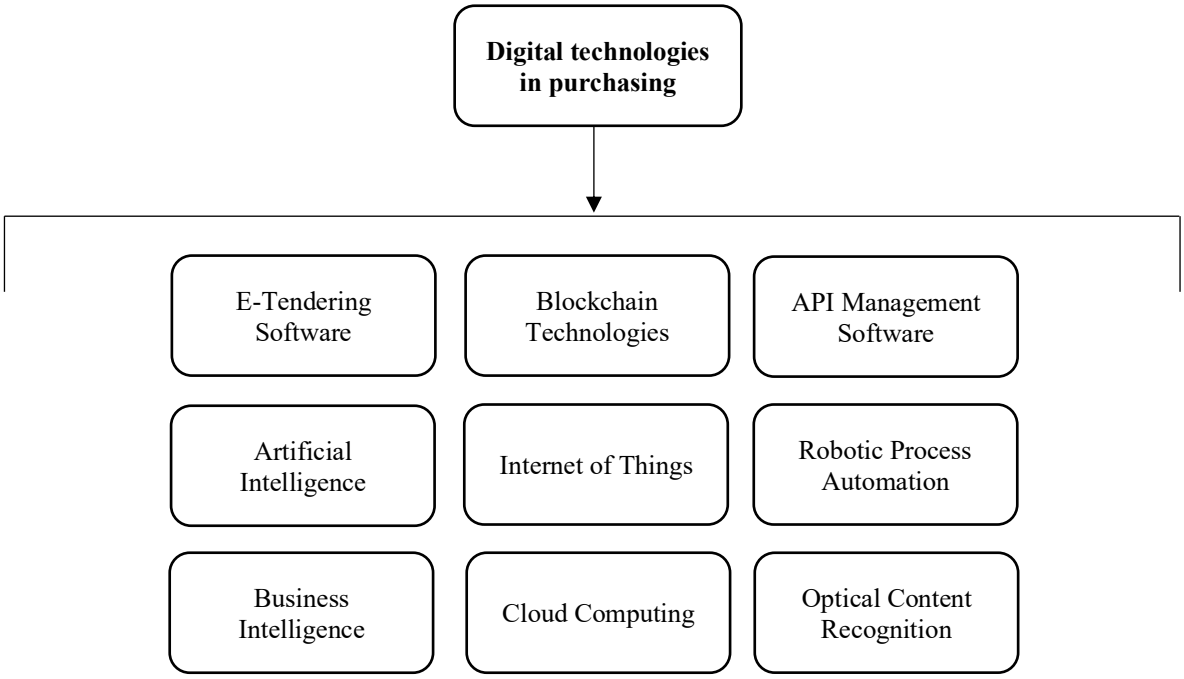
Previous research has shown that purchasers spend a lot of time answering questions coming from the internal organisation (I. 1). An example of reducing the time that is spent to answer these questions is the use of a mobile application. A purchasing application might provide all the information on suppliers, their contracts and what to do with a new tender (I. 5, 15). An application helps to purchase while considering the purchasing policy, laws and regulations and using tender examples (I. 15).

After defining the interest of digitalising public purchasing, the digital technologies that have been found in research are described in the next paragraph.

4.2 Digital technologies found in research

This paragraph provides information about the different digital technologies that can be included in public purchasing according to the interviewees. These digital technologies include: E-tendering Software, Optical Content Recognition, API Management Software, Business Intelligence, Cloud Computing, Blockchain, Internet of Things, Robotic Process Automation, and Artificial Intelligence (see figure 8). After all digital technologies have been described, table 5 provides a short description of all mentioned technologies.

Figure 8 Technologies mentioned in the interviews



4.2.1 Technology 1 - E-Tendering Software: using advanced functionalities leads to less complexity and cost savings

The EU has forced public organisations to digitalise source-to-contract activities (I. 2, 3, 8, 12, 14, 15). Therefore, e-tendering software must be used (I. 2, 3, 8, 12, 14, 15). The law for e-tendering can be seen as an important step in digitalisation (I. 3, 8, 12). E-Tendering Software helps to make the purchasing process less complex by offering digital support throughout the entire PPM (I. 8, 15). For example, with the use of an intake module how to start an order (I. 6). In this way, all tender documents are collected in one place (I. 2, 6, 15). According to interviewee 6, the software helps to structure information and make connections with the spend, the tender, the contract, and the suppliers. Also, organisations can make predictions based on past-performance data and use these lessons in the future (I. 6).

Most organisations only use the basic functionalities which include sending an RFQ, publishing a tender, and making it unable to open the proposals before a deadline (I. 1, 9). Whereas the advanced functionalities can be automatic scoring, answering questions, analysing price sheets, or determining the cheapest supplier (I. 1, 2, 6, 9, 12, 14).

Nowadays, many purchasers assess through Excel and upload documents in the software, while a purchaser can score through the software (I. 14, 15). Also, questions are often discussed by e-mail while the software allows directing the questions to a specific employee (I. 1, 2, 12, 14, 15). Besides, with the use of the question and answer (Q&A) module, purchasers can directly find the information that belongs to the question (I. 12, 14). When advanced functionalities are not used, the software is not used to the fullest. Often organisations do not have enough data and the knowledge to use advanced functionalities (I. 1). Therefore, organisations should invest in training their employees (I. 1).

4.2.2 Technology 2 - Optical Content Recognition: reads digital documents and retrieves information from it

Optical Content Recognition (OCR) tools can read documents and retrieve information from it (I. 6, 9, 15). Nowadays OCR is widely used in different departments. For example, in HR, OCR is used to match curriculum vitae with a vacancy (I. 6). Also, within finance, OCR is able to read invoices and send the required information to the financial system without having an employee fill in numbers (I. 9). Subsequently, OCR can be used in contract management to read, analyse, digitalise, and process contracts (I. 6). An employee used to perform these repetitive actions which can now be done by a digital application (I. 15).

4.2.3 Technology 3 - API Management Software: allows applications to communicate

Application Programming Interface (or API) is a new type of software that allows applications to “talk” to each other (I. 1, 8). APIs enlarge the openness of data in a way that the exchange of data with other applications is simplified (I. 6). With the use of APIs between data can easily be exchanged between applications (I. 6, 8). Therefore, the software must be in the cloud since an API system is a cloud-based technology (I. 8). By connecting applications, patterns can be discovered and follow-up actions can be taken (I. 6, 8).

According to interviewee 8, this form of digitalisation is easy and inexpensive. Because many organisations work in the cloud, the use of APIs has grown (I. 8). However, many

public organisations are unaware of this technology and lots of money for manual connections between systems (I. 8)

By using APIs, applications can be connected and conclusions can be drawn. For example, the sales system can be linked to the purchasing system to give insight into what to buy and automatically create purchase orders (I. 8, 9, 14). Also, it is valuable to link the tender with the contract, and the contract with the purchase-to-pay software (I. 1, 8, 14). In addition, contracts can automatically be sent to the contract management software that is used and the data transference can be done automatically instead of doing this by hand (I. 1, 8). When connecting applications such as financial, supply, purchasing or facility, information management increases and makes digitalisation possible (I. 8).

4.2.4 Technology 4 - Business Intelligence: improve steering information

Business Intelligence (BI) is focused on improving the basis of information (I. 5). With the use of BI, organisations can build a dashboard to analyse and improve their information basis (I. 5, 15). These dashboards can be used by managers to formulate strategies (I. 15). Often the use of BI and retrieving valuable steering information from it is seen as the first step that many organisations should apply (I. 15). BI can, for example, detect fraud by recording the budget and awarded value of tenders with the use of strategy documents (I. 6). Therefore, process mining can be considered a complement of BI (I. 6).

Process mining can be used as a tool to discover trends (I. 6). It can determine when mistakes are made in the purchasing process and how it can be optimised (I. 6, 13). Also, fraud can be detected by discovering patterns (I. 6). According to interviewee 13, process mining can be used in three ways. Firstly, to perform analysis on the front side to check whether the process functions as planned and determine how the pain points when the process does not go as planned (I. 13). Secondly, to perform analysis on the back side, for example on an RPA to check whether it performs as planned (I. 13). Thirdly, for continuous improvement (I. 13).

4.2.5 Technology 5 - Cloud Computing: the first step in digitalising public purchasing

Working in the cloud can be seen as the first step towards a digital organisation (I. 4, 8, 10). As a result of COVID-19, many organisations started to work in the cloud (I. 4, 9). Working in the cloud ensures that everyone in the organisation can access the work, which also leads to more transparency (I. 1, 4, 6). Also, this allows organisations to work on smart devices in different places (I. 1, 6). Data can run endlessly when an organisation works in

the cloud, both in size and in combining intake management, tender management, and contract management (I. 6, 8).

Especially in public organisations data security is an important topic (I. 4). Storing data in the cloud will assure continuity and safety of information (I. 8). Currently, almost all public organisations work in the cloud which makes them less dependent on IT (I. 1). However, public organisations make little use of software in the cloud (I. 8). In other words, having the largest part of the technical infrastructure in the cloud (I. 8). Therefore, according to interviewee 8, infrastructure needs to be based less on the old-fashioned service structure and more on cloud technologies. Only then will an organisation benefit from having good data security, access to that data, and the exchange of data between systems (I. 8).

4.2.6 Technology 6 - Blockchain: increases the traceability and reliability within an organisation

Blockchain can be seen as a joint decentralised administration (I. 1). Nowadays, blockchain is mainly used within production organisations (I. 1). This digital technology has already passed its hype phase, which could make it an interesting technology (I. 1). However, according to several interviewees, many public organisations are hesitant to apply blockchain (I. 2, 6, 12, 13). The use of blockchain does not always lead to more efficiency in organisations (I. 2, 6, 12, 13). Sometimes a solution seeks a problem (I. 6). Also, it is difficult to apply blockchain in public organisations because sometimes big changes in processes need to be made (I. 2, 6, 12, 13).

This digital technology can be applied in topics such as the traceability, reliability, and recording of information in a chain (I. 1, 6, 9). In the supply chain, blockchain is used to gain information about the traceability of products. For example, by having knowledge of non-toxic substances and the working conditions (I. 1, 9). Also, blockchain helps to improve reliability (I. 1, 6). For example, to question whether the product can be trusted, whether the supplier can be trusted, whether there is no child labour, and whether the certificate is correct (I. 1). Subsequently, blockchain can be used in combination with IoT (I. 1). According to interviewees 1 and 9, an example of the application of these technologies is when a lamppost is not working. In this case, an automatic signal is sent to the supplier that maintenance must be carried out (I. 1, 9). Once the lamppost is serviced and checked, an automatic signal is sent to the procurement department and payment is done (I. 1, 9). This signalling system (IoT) helps to close the chain (I. 1).

4.2.7 Technology 7 - Internet of Things: provides valuable data through a sensor

Internet of Things (IoT) is a sensor that can digitalise information (I. 8). IoT must be able to communicate with the internet to transfer information (I. 8). However, not all sensors can communicate with the internet everywhere (I. 1). According to interviewee 1, the introduction of 5G will help have sensors communicate better with the internet, everywhere. This will provide more available data for all kinds of applications (I. 1). With the combination of IoT and 5G, the business case is stronger (I. 1).

IoT is applicable in facility management since it controls working activities of topics such as heating, lightings, gates, supply, and water (I. 8). In addition, this technology is useful in evaluating the purchase (I. 6). Also, when it comes to measuring performance which is agreed in a contract, IoT offers potential (I. 6). IoT can measure the entire IT infrastructure and translate it to KPI dashboards and contracts. Therefore, it has the potential to improve purchasing (I. 6, 8).

4.2.8 Technology 8 - Robotic Process Automation: used to reduce administrative workload by exchanging data between systems

Robotic Process Automation (RPA) is used to exchange and connect data between systems and reduce manual repetitive administrative work in an organisation (I. 1, 2, 3, 8, 11, 13). RPA is an accessible technology and is already applied within the purchasing department of several public organisations (I. 2, 8, 11, 13, 16). It can be applied to, for example, connecting an ERP system with the purchase system; the purchase system with the financial system; the purchase system with the inventory system; the sales system with the stock system, with the purchasing system (I. 8, 13). Manual processing of data takes a lot of time and is vulnerable to making mistakes (I. 2, 9). An RPA algorithm processes data automatically, reduces mistakes, is more accurate and faster (I. 2, 4, 8, 9, 10, 11). This allows employees to spend more time on tasks that require human thinking which increases job satisfaction (I. 7, 10 11, 13).

To determine whether RPA is applicable, organisations should review the degree of transactionality, the degree of standardisation, the volume, the degree of structured data, and the repetitiveness (I. 11). The higher the criteria, the better applicable RPA is (I. 11).

An RPA algorithm performs actions based on a script (I. 8, 11, 13). This script describes what to do when (I. 8, 13). With the use of scripts, RPA can also be applied in combination with chatbots. An RPA chatbot can collect answers from several databases and reply to questions coming from both internal and external parties (I. 13). Since RPA only provides

answers based on a script, it is considered a sub-optimalisation of digitalisation (I. 1). RPA is compared to AI, not a smart technology (I. 10, 13). RPA can perform repetitive tasks, while AI is self-learning and continues to develop (I. 13).

4.2.9 Technology 9 - Artificial Intelligence: organise, interpret, and combine data

Artificial Intelligence (AI) organises data to information, interprets and combines data, and increases the reliability and efficiency in an organisation (I. 1, 4, 8). It helps to combine data to structure, find patterns, and get information from a big amount of data which cannot be done by an employee (I. 1, 10). This technology is self-learning and continues to develop based on performances (I. 13).

The development of AI goes fast (I. 1, 13). Therefore, organisations should start now with small applications (I. 1). Based on an algorithm, AI performs activities (I. 1, 10). An open-source community, open AI, has publicly available algorithms that can be used for free (I. 1). This makes the adoption and experimentation level easy and low in costs (I. 1).

Like RPA, AI will take over a large part of the administrative work (I. 1). However, it is not expected that applying AI will lead to fewer employees since the human element will always be necessary (I. 6). When using AI, the organisation needs a data scientist to train algorithms (I. 1, 5).

Nowadays, there are not many concrete applications of AI within purchasing since organisations often lack knowledge on the subject (I. 8, 14). This digital technology is used by multinationals that have huge amounts of data (I. 1, 10). Currently, the automotive sector can be seen as a leader in the use of AI (I. 1). Even though AI is mainly applied in big private organisations, it can also be very helpful for public organisations (I. 10). For example, conversational AI (chatbots) can be used to answer questions. Research shows that purchasing employees in specific municipalities spend up to 30 per cent of their time answering questions from both internal and external parties (I. 1). Therefore, it can be very useful to have an AI bot answering questions (I. 1, 4, 13).

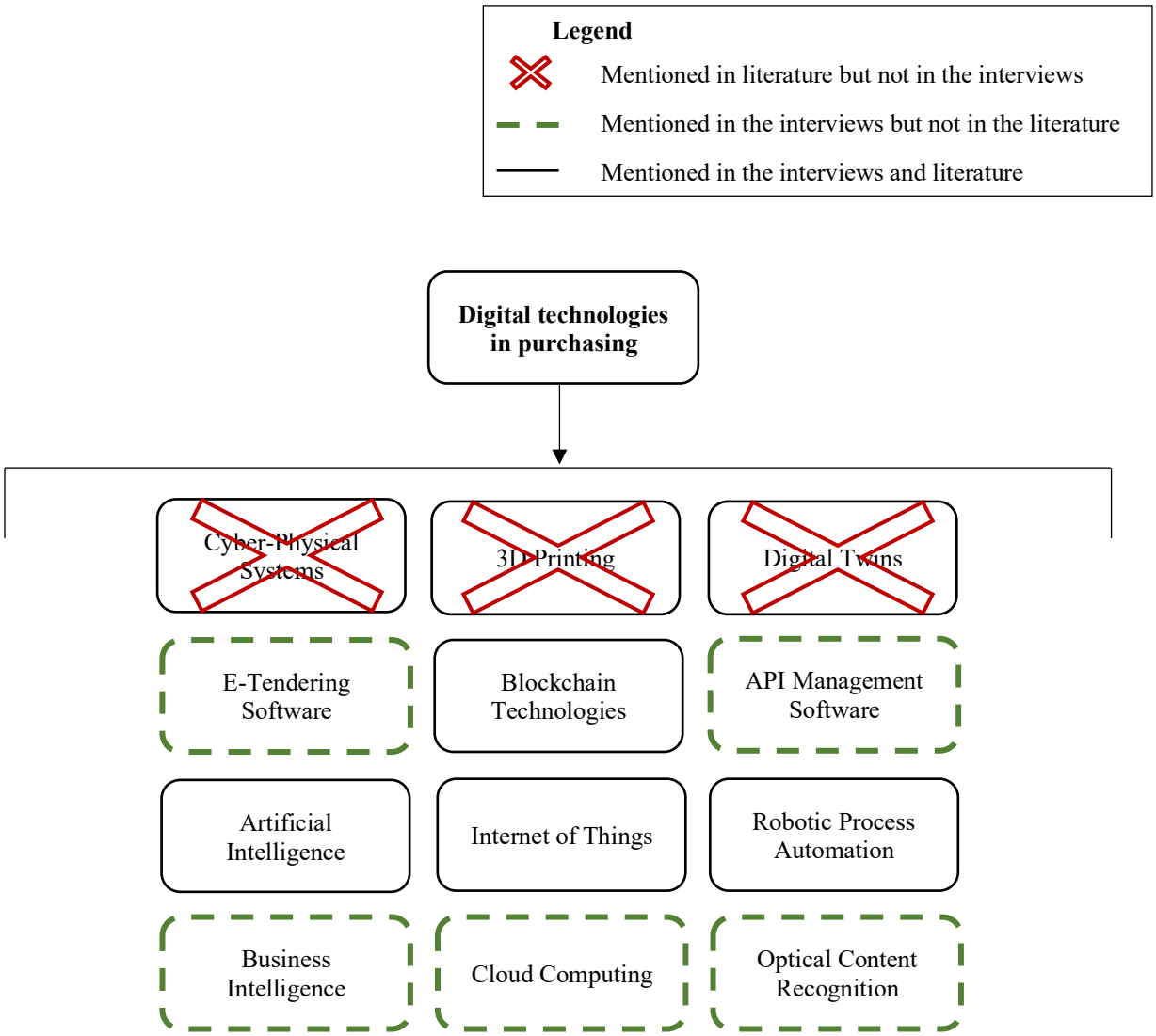
4.3 Summary of applications that can be used in public organisations

After describing the digital technologies that were mentioned in the interviews, a short description of each form of digitalisation is provided in table 5. Hereafter, figure 10 provides an overview of the digital technologies found in the literature and the interviews. The figure shows which technologies were not found in the literature but were mentioned in the interviews and the other way around. The underlying reasons are discussed in chapter 5.

Table 5 Overview of digital technologies explained

E-Tendering Software	Public organisations are forced to digitalise all source-to-contract activities with the use of e-tendering software (I. 2, 3, 8, 12, 14, 15).
OCR	Optical content recognition (OCR) tools can read documents and retrieve information from it (I. 6, 9, 15).
API Software	Application Programming Interface (or API) is a new type of software that allows applications to "talk" to each other (I. 1, 8).
BI	BI is focused on improving the basis of information with the use of data analysis. Also, process mining is considered to be a complement of BI to discover trends within the organisation (I. 6).
Cloud Computing	Cloud computing ensures that employees can access information everywhere (I. 1, 4, 6).
Blockchain	Blockchain is a decentralised administration and ensures that every participant has equal read and write permissions. A chain is closed when all participants have approved (I. 1).
IoT	IoT is a sensor that can digitalise information. IoT is especially useful to control working activities, for example in facility management (I. 8).
RPA	RPA is used to exchange and connect data between systems (I. 8, 11).
AI	AI organises data to information, interprets and combines data, and increases the reliability and efficiency in an organisation (I. 1, 4, 8).

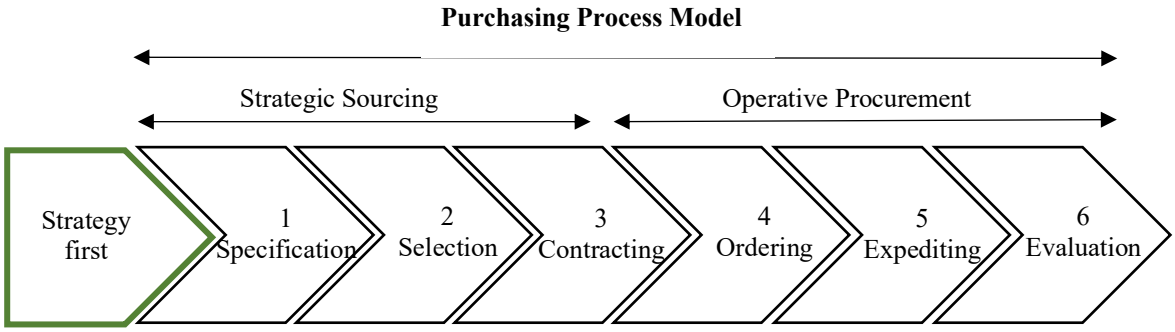
Figure 9 Overview of different technologies mentioned in literature and interviews



4.4 Applying digital technologies in the Purchasing Process Model of Van Weele

This paragraph describes the application of digital technologies in the PPM from Van Weele. Based on the interviews, the PPM must be extended with a strategy phase, followed by the other phases. Therefore, this phase is included in the PPM of Van Weele, as shown in figure 10.

Figure 10 Strategy and the Purchasing Process Model



4.4.1 Determining a strategy is an important first step in the purchasing process

The PPM of Van Weele starts with specification, while according to multiple interviewees, strategic purchasing must be the first step if a public organisation wants to digitalise and professionalise, as given in figure 10 above (I. 3, 4, 5, 6, 8, 13, 16). Strategic purchasing means determining the need and the types of products and services that must be purchased (I. 4, 5, 8). In other words, determine the category management (I. 4, 8).

Based on category management, decisions can be taken on how to procure (I. 4, 5, 8). Category management can be performed with the use of software (I. 4). This helps to formulate a strategy in short term to determine the most important suppliers and elements (I. 4).

Important tooling for category management is spend analysis (I. 3, 8). AI can be used to digitalise spend analyses by recognising invoices, contracts, and spend (I. 1, 5, 6, 12). By recognising the spend, an AI algorithm can link these to the specific purchasing package that belongs to a category (I. 1, 5). Also, AI can make predictions for future spend (I. 12). Another application for digitalising the spend analysis is with the use of RPA by linking invoices with the purchase-to-pay system (I. 8, 12). This will provide the organisation with real-time information which might lead to cost savings (I. 4, 8, 9). In addition, BI can be used to build dashboards and make analyses based on the spend data (I. 5, 15). All these digitalisation methods will reduce administrative work (I. 5).

Another important step in defining the purchasing strategy is performing a market analysis (I. 5, 10). Often organisations build tender documents with the use of documents from a former tender (I. 3, 5, 16). However, according to interviewee 5, organisations then forget to take market development into account. It is important to be aware of the market opportunities, the positioning of the organisations according to others, and how the product or service must be purchased (I. 5). Having sufficient knowledge about the market and the possibilities of the suppliers, the tender can be targeted to get the best out of the market (I. 5). Market analysis can be digitalised with the use of AI in the form of a web scraping bot (I. 5, 10). Web scraping is an algorithm that can perform research on different platforms such as the internet, forums, digital newspapers, and specific communities (I. 5, 10). For example, to gain information on a few suppliers, frequently used terms and what is going on in the market (I. 2, 5, 10). The algorithm creates a fore selection of information and gives a dashboard of the most relevant information (I. 5). In this way, information overload is prevented (I. 10). This form of AI is not often used in public organisations, while it can be a small step that can be taken easily (I. 2, 10).

	Experts
	Public organisations

Table 6 Interviewees who determine that AI, BI, RPA, web scraping and software can be used to digitalise a purchasing strategy

Interviewee	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Category management																
Software																
Spend analysis																
AI																
RPA																
BI																
Market analysis																
AI and web scraping																

4.4.2 Phase 1 - specification: using digitalisation to formulate tender documents

Within the specification phase, purchasers determine the demand and define award criteria (I. 2, 3, 12). This requires manual work and often even requires conducting interviews to determine what to purchase (I. 2, 3). Within this phase, public organisations experience high risks (I. 6). After publishing a tender, adjustments cannot be made anymore (I. 6). A winner must be awarded based on the specifications of the published tender (I. 6).

At first, e-tendering software helps to assist non-purchasers to take the right steps in the purchasing process (I. 6). Many organisations still use Word to compose tender documents and upload these in the e-tendering software, while documents can also be composed through the software (I. 6, 14, 15). Composing documents in the software increases efficiency since this allows purchasers to structure information and collect all tender documents in one place (I. 2, 6, 15).

Due to the fear of finalising a tender and being proceeded, many organisations use former tender documents as an example to formulate new tender documents in the specification phase (I. 3, 5, 10). However, this slows down the gathering of information (I. 5). Making tender documents requires a lot of time and can be digitalised with the use of a document-generating system (I. 16). By answering several questions, the tool can automatically generate the tender document. The generator formulates the tender documents faster and more carefully, taking into account all necessary knowledge, laws and regulations (I. 16).

Another application of digitalising tender documents is shown in the United States of America (USA) (I. 1). In the USA, tender documents are generated with the use of AI and web scrapes (I. 1, 5). With the use of these technologies, tender documents are automatically completed for 60-70 per cent (I. 1, 5). To generate these documents, the algorithm can be trained with all tenders that are published on TenderNed (I. 5). The algorithm analyses what happened in a tender, develops patterns and creates strategic insights (I. 5). Conclusions about topics such as the lead time, criteria, quality, and price can be made and correlations can be found (I. 1, 5). Yet, it is not often used in practice (I. 1).

Finally, most information that is provided in documents used in the first purchasing phase, is often also necessary in other documents, such as the contract (I. 9, 12). Therefore, RPA can be very useful to automatically transfer information and build documents which are necessary for other phases of the purchasing process (I. 9).

	Experts
	Public organisations

Table 7 Interviewees who determine which digitalisation methods can be used to generate tender documents

Interviewee	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
E-tendering software																
Document-generating system																
AI and web scraping																
RPA																

4.4.3 Phase 2 - selection: retrieving supplier information and answering questions with digital applications

The law for e-tendering forces all public organisations to publish tenders electronically (I. 8). As a result, e-tendering software has collected data about all tenders that have been published (I. 5). This means that the software contains very valuable information such as potential suppliers according to the size of the organisation, specific topics such as sustainability or refurbished equipment and lawsuits (I. 1, 5). This data will provide public organisations with valuable supplier information to perform the tender and select a supplier (I. 5). This data cannot be used by public organisations due to the law that requires public organisations to give all suppliers a chance to take part in a tender (I. 5). Therefore, the law must be adjusted and interviewee 5 expects that organisations might be able to use this data in the future.

Within purchasing, very little cross event analysis is done (I. 1). With the use of cross event analysis, an organisation can gain insight by reviewing a supplier that participates in a tender (I. 1). By looking at historical offers from a supplier, a certain pattern about how they offer and the increase or decrease of prices can be discovered (I. 1). This is considered to be a missed opportunity in purchasing (I. 1). Also, organisations usually only record the prices of the winner of a tender in the contract management system. According to interviewee 1, the prices of the potential suppliers that lost the tender are not used at all while this could be very valuable data for an AI algorithm to make price predictions (I. 1).

E-tendering software can support answering questions coming from suppliers (I. 1, 2, 12, 14). According to interviewee 14, the software provides a good overview of the requirements. When a supplier has a specific question, this will be linked to the exact part in the document (I. 14, 15). These questions can also be sent through the system to a project

team member that can answer (I. 2, 12, 14). This makes it more concrete for both the purchaser and the potential supplier to search for information (I. 14).

In addition, questions coming from (potential) suppliers can be answered with the use of RPA in combination with chatbots. RPA collects answers from several databases based on a script (I. 13).

A more advanced application of chatbots is in combination with AI. In the USA, which has a pioneering role in terms of the innovation of AI, AI in the form of chatbots is used to answer questions regarding a tender. In this way, all questions that usually need to be submitted when issuing a quotation, are automatically answered (I. 1). AI is more advanced since this technology is self-learning (I. 1, 13). When the algorithm cannot provide an answer, the question is directed to an employee (I. 1). Hereafter, the AI algorithm will remember and learn from the answer the employee gives (I. 1). In this way, the algorithm is trained and able to answer a similar question in the future (I. 1).

Also, many public organisations use Excel to assess potential suppliers (I. 6, 12, 14). With the use of e-tendering software assessing can be digitalised since purchasers can assess through the software (I. 1, 6, 14, 15). Assessors can be added for each award criterion (I. 14, 15). Eventually, the system will automatically give the result of the tender, based on the scores that have been given by the assessors (I. 14, 15).

	Experts
	Public organisations

Table 8 Applications mentioned to digitalise topics in the selection phase

Interviewee	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Retrieving valuable supplier information																
E-tendering software																
Cross-event analysis and AI																
Answering questions																
E-tendering software																
RPA and chatbots																
AI and chatbots																
Assessing (potential) suppliers																
E-tendering software																

4.4.4 Phase 3 - contracting: generating contracts with AI or RPA

According to several interviewees, the digitalisation of contract management (CM) is even behind purchasing (I. 5, 9). Especially in public organisations, the field of contract management is underdeveloped (I. 9). Currently, contract management systems are operational and are used to digitalise old processes (I. 3, 5). The front is digitalised, while the back is an Excel spreadsheet (I. 3, 5, 6, 7, 9). By adding intelligence to the existing information, organisations can create more value (I. 5).

Currently, there are barely any links between the tender system and the archive of the contract management system (I. 9). To take part in the tender, a potential supplier must fill in all the company details (I. 12). When the supplier is awarded, a contract must be composed and these details must be manually filled in (I. 11, 12). Most information that is used in the contract is already submitted by the supplier in the tender (I. 12). Therefore, it is useful to transfer this information automatically and generate a contract with the use of RPA (I. 9, 12). This avoids recording information twice in different systems and increases job satisfaction by reducing administrative tasks (I. 1, 7, 9, 10, 11, 12).

Another application that can be used to generate contracts is AI. AI can help to get data structured and more complete to create more efficiency (I. 1). Currently, in many organisations, data is not correctly structured and therefore often not trusted to base a decision on (I. 1). According to interviewees 1 and 4, AI can automatically generate contracts after answering a few mandatory questions in the algorithm. Therefore, the algorithm should have the information from the tender documents (I. 1, 4). Then it will be able to create a template with the correct topics such as warranty clause, processing agreements, liability, direct and indirect damage (I. 1). The algorithm will base the templates on past tenders and contracts (I. 1). This will improve the efficiency and effectiveness of contract generations (I. 1, 4). Also, since the AI algorithm can read contracts and advise on clauses, contracts can be generated with far fewer people (e.g., legal specialists) (I. 1).

Contract management is often not correctly centralised within the organisation (I. 5). Many employees are not aware of who has the information on the different contracts (I. 5). Therefore, a mobile application can be used to provide an overview of all registered contracts (I. 5, 15). In this way, every employee can see whether a contract is available (I. 5). When a contract is not available, an intake form in the application can help the employee to check framework contracts (I. 5, 15). This increases the legality of public organisations by preventing employees from maverick buying (I. 8).

A final method for digitalising the contract phase is by using applications to read contracts and retrieve information from it. OCR and AI can read contracts and retrieve metadata from it (I. 1, 6). AI is more advanced and can structure contract management by reviewing the entire database and checking where the gaps in contracts are and what is missing (I. 9). Often, organisations have contracts in a pdf document of 10 to 15 pages long which is poorly administered (I. 1). In most cases, only the start and end date are recorded in the system, while information such as an automatic extension or a cancellation period, contract value and milestones can be valuable (I. 1, 5). AI can extract the metadata from all contracts that are uploaded and can automatically put it in the system (I. 1).

	Experts
	Public organisations

Table 9 Contracting can be digitalised in several ways

Interviewee	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Generating contracts																
RPA																
AI																
Providing an overview of all registered contracts																
Mobile application																
Read contracts and retrieve metadata																
OCR																
AI																

4.4.5 Phase 4 - ordering: improving efficiency with a purchasing catalogue

The purchase-to-pay process of placing an order, receiving the invoice, and handling the payment is not yet common in many organisations (I. 7, 8, 9). Digitalising the ordering phase will increase efficiency within the organisation (I. 3, 8).

To digitalise the ordering phase, organisations can use a purchasing catalogue that handles the entire purchase-to-pay process (I. 8, 14). A purchasing catalogue helps to place framework contracts in a catalogue to allow users to place orders themselves and register the spend (I. 2, 7, 8). The catalogue allows employees to purchase directly from one interface (I. 7, 8). It contains websites of suppliers with whom the organisation has a framework contract (I. 7). The catalogue offers a link with the website of the supplier and considers all purchasing conditions (I. 7, 8). It translates the business-to-business purchasing experience more towards a business-to-consumer experience of shopping (I. 1, 16). The use of catalogues makes the purchasing process cheaper and more efficient since users do not have

to spend time searching for a product and the financial administration is easier (I. 7, 8). This also prevents maverick buying (I. 8).

Depending on the amount, the catalogue can use two- or three-way matching (I. 7). Public purchasing is considered more complex and often requires three-way matching (I. 7). With the use of three-way matching, the receiver must determine through the catalogue that the order has arrived and the invoice can be paid (I. 7). In other words, after the product or service is received and accepted the payment will take place (I. 7, 9).

Subsequently, QR codes can be used to digitalise package delivery (I. 8, 14). After scanning the QR code on the package, the arrival of a product is approved (I. 14). This will result in linking the arrival with the purchase order to determine that the payment can be made (I. 14).

	Experts
	Public organisations

Table 10 Digital applications mentioned related to ordering

Interviewee	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Ordering																
Purchasing catalogue																
Registering the order																
QR codes																

4.4.6 Phase 5 - expediting: increasing efficiency of invoicing with QR codes

The European Union (EU) continues to develop and determines conditions on interoperability by defining which language is spoken between countries (I. 6). For example, since 2020, e-invoicing is obligated (I. 6, 9). Since then, all invoices must have the same standards (I. 9). Currently, invoice handling happens in an inefficient and costly way (I. 8). Digitalisation can increase efficiency and reduce costs by 25 per cent in the financial department by reducing the number of employees (I. 7, 8). The expediting phase can be digitalised in several ways.

At first, QR codes can be used to make payments. For example, in restaurants, bars, or meeting locations (I. 16). Since most locations are not able to send e-invoices, a QR code is used (I. 16). After scanning the QR-code the e-invoice is automatically sent to the finance department. This reduces the speed of invoice handling and making the payment (I. 16).

Also, The EU has published the European PEPPOL system which controls all invoices (I. 8). Every supplier must deliver personal and business information such as the chamber of commerce number (I. 8). Sending an invoice always goes through the PEPPOL system, which proves that the supplier is legitimate (I. 8).

Subsequently, RPA and OCR can be used to read an invoice and detect order numbers (I. 8, 9). When the software cannot find an order number, RPA can detect other numbers which might link the invoice to the purchase (I. 8). Besides linking the invoice number with the purchase number, RPA will prevent double payments. In this process there is no need for manual work which means that it reduces the necessary employees, reducing costs and risks (I. 8).

After retrieving data from the invoice, invoices must be matched with purchase orders (I. 8). Currently, this is done in several ways: manually, inefficiently automated, automated without checks, or completely automated providing only the exceptions (I. 8). The latter is the most efficient that can be achieved with the use of RPA (I. 8). The software can connect two data streams and match the invoice with a purchase order (I. 8).

In addition, AI can be used to register incoming invoices (I. 1, 7). Just like RPA, AI can recognise invoices and match these invoices with orders (I. 1). By including this digital technology, the organisation can reduce the administrative work of processing invoices (I. 1). Organisations work more efficiently since fewer employees are needed to make spend analyses in tables and graphs (I. 1). The AI algorithm can read the invoice and automatically code it to the specific purchasing group. This increases efficiency to make spend analysis (I. 1).

	Experts
	Public organisations

Table 11 Digital methods to improve the efficiency of invoices

Interviewee	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
E-invoicing																
QR codes																
PEPPOL system																
Read and process invoices																
OCR																
RPA																
AI																

4.4.7 Phase 6 - follow-up and evaluation: measuring supplier performances and obligations with digitalisation

Within this phase, the purchased product or services are evaluated which involves supplier relationship management (SRM) and contract extensions (I. 1, 3, 6, 8). The supplier performance is discussed, and the supplier is evaluated (I. 1, 6). Purchasing is about building a relationship with a partner to reach the ultimate result (I. 6). Especially for public organisations, the objective is to run an improvement program with the supplier to increase the public value (I. 5). However, SRM is not often used to the fullest within public organisations (I. .3).

Information about contacts within the organisation is usually not centralised (I. 5). Digitalising with a contract management tool can assist in providing contract managers with an overview of obligations, both financially and practically, risks and sending invoices (I. 5). While digitalisation of contract management should help organisations on a daily basis by sending notifications when a contract is about to expire and when the supplier performance level is under an agreed level (I. 5).

At first, digitalisation can improve contract management by sending push notifications when a contract must be extended (I. 5, 6, 8, 9). To determine when a contract must be extended, it is important to know when a contract is about to expire (I. 7, 10). With the use of a contract management tool, organisations will receive a push notification when the contract is about to expire (I. 7, 10). Also, publications must tender again or extend the contract when the budget that was expected for a supplier is exceeded (I. 9, 12, 14). With the use of RPA, an organisation can receive push notifications when the expected value of the framework is exceeded and must be extended (I. 9, 12, 14). RPA is applicable since it can connect the utilisation and the maximum contract value with the purchase-to-pay module (I. 12).

In addition, measuring supplier performance in a digital system with notifications is not used in public organisations and is barely used in private organisations (I. 5, 6). Digitalisation can help to evaluate KPI's and obligations (I. 9). By using a contract management system for SRM an organisation is able to measure supplier performance and determine whether the promise that was made in the tender corresponds with the performance (I. 5, 6). If the organisation is not able to make this comparison, it cannot determine whether the right supplier was awarded (I. 6). This might also increase trust for the future of purchasing and award suppliers more easily based on proven performance (I. 6). Also, a contract management system can be used to send notifications when the supplier

performance is below an agreed level (I. 6, 9, 10, 14, 15). This tool allows contract managers to assess KPI's on a contract (I. 6).

Also, IoT can be used to measure supplier performance by questioning users about the experience of the product or service (I. 6). For example, to assess how clean a toilet is or to detect the number of leaves on the road so that sweeping can be planned (I. 6).

Finally, the performance of a purchased product is digitalised and improved with the use of blockchain and IoT. When a product or device contains an IoT sensor, the sensor can communicate with the organisation when something is wrong (I. 1). With the use of an automatic signal fewer manual controls have to be performed (I. 1). The system is able to follow a workflow and send a notification when maintenance must be carried out (I. 1). After the maintenance is performed the sensor automatically sends a notification that the product or device is working again, which closes the chain (I. 1).

Table 12 Increasing supplier relationships by applying digital methods

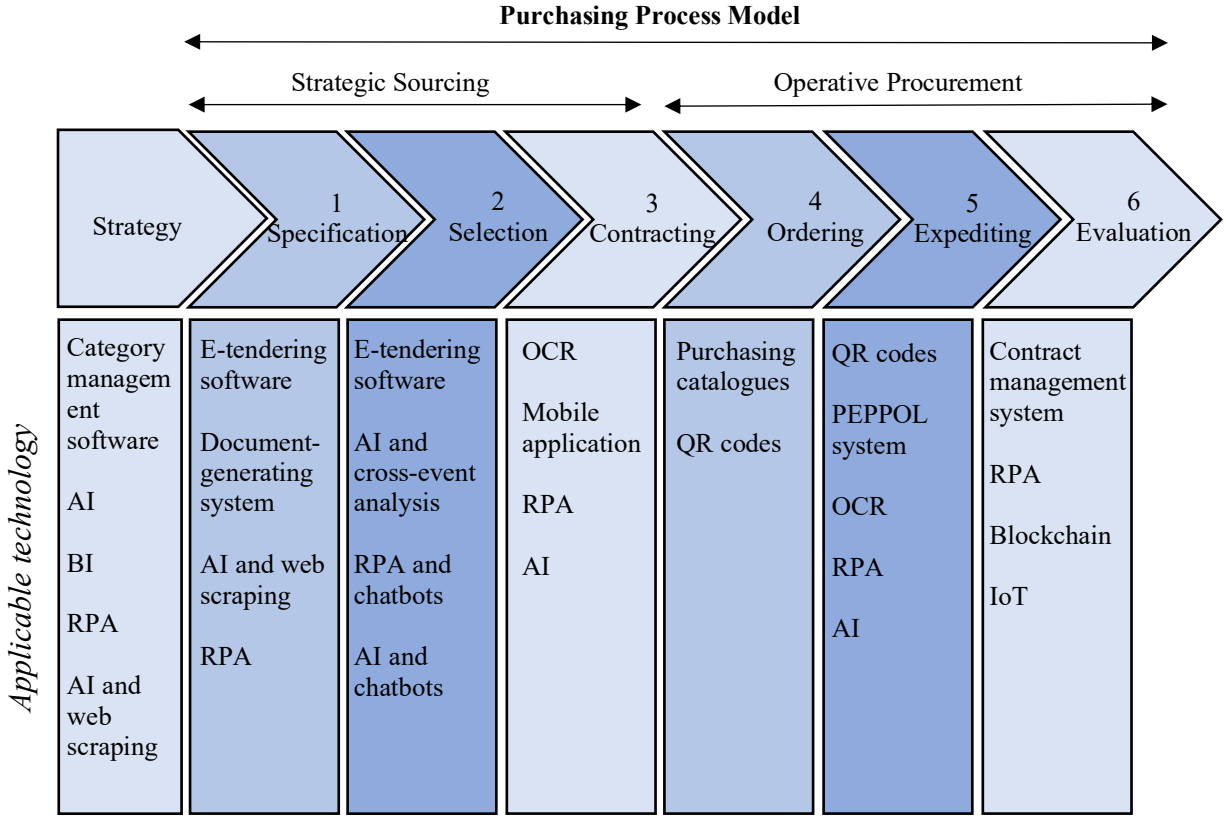
	Experts
	Public organisations

Interviewee	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Contract extension																
CM tool																
RPA																
Measuring supplier performance																
CM tool																
IoT																
Controlling the purchased product																
IoT																
Blockchain																

4.5 Synthesis of the results regarding the Van Weele Purchasing Process Model

The results described which technologies can be used in each phase of the PPM of Van Weele. In figure 11 below, an overview of the applicable digital technology per phase is given.

Figure 11 Applicable technology per phase



In short, the results show that strategy must be included in the PPM. To build a strategy, organisations can use category management software and can digitalise spend analysis with the use of AI, BI and RPA. In addition, public organisations must perform market analysis with the use of AI and web scraping.

In the specification phase, many tender documents must be composed. Therefore, e-tendering software, a document-generating system, RPA, and AI in the form of web scraping can be used.

In the selection phase, a database from the e-tendering software and cross-event analysis with the use of AI can be used to retrieve supplier information. Also, questions can be answered more efficiently with e-tendering software and chatbots with the use of RPA and AI. Finally, assessing suppliers can be digitalised with e-tendering software.

In the contracting phase, several digital tools can be applied. RPA and AI can be used to generate contracts. Also, a mobile application can be used to provide an overview of all registered contracts. Finally, OCR and AI can read contracts to retrieve metadata.

In the ordering phase, digitalisation can be included by using purchasing catalogues for the purchase-to-pay process. Also, QR codes can be used to register incoming packages.

In the expedition phase, an organisation can increase efficiency with digitalisation regarding invoices. QR codes in restaurants can be used to make an e-invoice which is sent to the financial department. Subsequently, PEPPOL system controls the legitimacy of suppliers. Also, OCR, RPA and AI can be used to read and process invoices.

Finally, in the follow-up and evaluation phase, a contract management tool and RPA can be used to digitalise the extension of contracts. Also, the contract management tool can be used to measure supplier performance. Finally, the purchased product can be controlled with the use of IoT and Blockchain.

Table 13 provides a concrete overview of the opportunities digital technologies have for each purchasing phase.

Table 13 Opportunities to digitalise each phase of the Purchasing Process Model

Strategy first	• Use category management software to make decisions on how to procure. • Digitalise spend analysis with AI, BI, and/or RPA and build a real-time dashboard. • Use AI and a web scraping bot to perform market analysis.
Phase 1: specification	• Use the intake module in E-tendering software to help non-purchasers to start a tender. • Use document-generating systems to build tender documents. • Generate tender- and strategy documents with the use of AI and a web scraping bot. • Use RPA or APIs to transfer supplier information to other documents.
Phase 2: selection	• Use the TenderNed database to retrieve valuable supplier information. • Use cross-event analysis and AI to review suppliers that participate in a tender. • Use e-tendering software to direct questions to employees.

	• Use RPA or AI chatbots to answer questions. • Use e-tendering software to assess potential suppliers.
Phase 3: contracting	• Use RPA or APIs to transfer supplier information to the contract. • Use AI to automatically generate contracts. • Use a mobile application to provide an overview of all registered contracts. • Use OCR to read and analyse contracts. • Use AI to read contracts and fill gaps in contracts.
Phase 4: ordering	• Use a purchasing catalogue to digitalise purchase-to-pay activities. • Use QR codes to link the delivery with the purchase order.
Phase 5: expediting	• Use QR codes to create e-invoices. • Use the PEPPOL system to ensure a supplier is legitimate. • Use OCR to read invoices. • Use RPA and AI to read and match invoices with orders
Phase 6: evaluation	• Use a contract management tool to receive notifications when a contract expires. • Use RPA to receive notifications when the budget for a supplier is exceeded. • Measure supplier performance with a contract management tool. • Use IoT to measure supplier performances. • Use blockchain and IoT to perform fewer control activities by the use of a sensor.

According to the research, RPA and AI are considered to be the most promising technologies. These technologies can offer solutions in almost all phases of the PPM process. However, according to several interviewees, it can be concluded that many possible digitalisation methods have not yet been developed within (public) purchasing. An important step public purchasing can make, is having a similar business-to-consumer experience. Which is, according to interviewee 5, a different approach to purchasing is not expected to happen in the near future. It can be concluded that the digitalisation of purchasing and contract management in public organisations stay behind private organisations. This can be explained by the laws and regulations public organisations must follow, but also the hesitance many public organisations have in purchasing new innovative technologies. This

goes in hand with the lack of knowledge in public organisations when it concerns the possibilities of digital technologies in purchasing.

It can be concluded that there are several methods to digitalise public purchasing and contract management. The first step to digitalise public purchasing and contract management is to start with cloud computing (I. 4, 8, 10). When organisations work in the cloud and have structured the basis of data, the following steps can be taken.

A second step in the digital transformation must be building up a purchasing strategy. This can be done by retrieving information from real-time data in the spend analysis with the use of RPA. Also, with the use of AI in the form of a web scraping bot organisations can collect additional information about suppliers and categories to build a strategy.

After creating a purchasing strategy, the current and desired processes, bottlenecks, and possible solutions must be formulated. This will provide an overview of processes that can be improved which allows the organisation to assess which type of technology can be applied (I. 3, 9, 13). It is important that organisations start small and expand over time (I. 1, 3, 4, 5, 8, 9, 13). With small steps, public purchasing can expand and experiment with more digital solutions (I. 5, 10). For example, to use digital technologies like AI, RPA or document-generating systems to build up tender documents and reduce time-consuming tasks. Also, using RPA or APIs to transfer data from one system to another, or use RPA to perform repetitive administrative tasks (I. 5, 8, 13, 15).

5 Discussion

Due to the lack of research in the field of digitalisation in public purchasing, this research aimed to fill the gaps in the literature by identifying how public organisations can apply digital technologies in purchasing and contract management to increase efficiency. To fill these identified gaps, this research has provided an answer to the research question: "How can digital technologies be applied in a public organisation to increase efficiency in purchasing and contract management activities?". To answer the research question, the research is focussed on three areas: determining the common interest of digitalisation in purchasing; digital applications; digital applications in the PPM from Van Weele.

5.1 Theoretical contribution: providing methods of digitalisation throughout the adjusted PPM

This research contributes to the literature by examining the PPM of Van Weele. Research shows that the original PPM must be modified by including the strategy phase as the first step (Bäckstrand et al., 2019, p. 4). According to several interviewees, a public organisation should start with strategic purchasing if it wants to digitalise and professionalise. By extending the traditional PPM with strategic purchasing, buyers are able to determine the need and the type of products and services that must be purchased. On the contrary, literature shows only six phases of Van Weele' PPM (Bäckstrand et al., 2019, p. 4; Tieman & Ghazali, 2013, p. 287; Van der Valk & Rozemeijer, 2009, p. 5). Therefore, the accuracy of the traditional PPM must be studied more thoroughly. This might lead to future researchers including the strategy phase to the PPM when this model is applied.

Also, this research contributes to the literature by providing several methods that can be used to digitalise the purchasing process. Within this research different digital technologies were found compared to literature. According to the research e-tendering software, API Management Software, BI, Cloud Computing, OCR, Blockchain, IoT, RPA, and AI are digital technologies that can be applied in purchasing. However, according to the literature, CPS, Blockchain, Digital Twins, 3D printing, AI, IoT, and RPA are the digital technologies from Industry 4.0 (Kumar et al., 2021, p. 1; Salkin et al., 2017, p. 3; Schiele et al., 2021, p. 4; Schiereck, 2021, p. 12; Srai & Lorentz, 2019, p. 2; Wang & Wang, 2016, p. 1). This concludes three groups: new, not found, and existing digital solutions. New solutions are e-Tendering Software, API Management Software, BI, Cloud Computing, and OCR, which are found in the interviews but not in the literature. On the other hand, not found solutions are CPS, Digital Twins, and 3D Printing. These digital technologies have not come to the

attention in any of the interviews. The existing technologies are Blockchain, IoT, RPA and AI, which have been found in the interviews and the literature.

The new digital solutions came to the attention in the interviews but were not provided in the literature. First, literature does not define e-Tendering Software as a digital technology. However, according to the interviewees, the obligation to use e-Tendering Software contributes to the digitalisation of purchasing in public organisations. Therefore, e-Tendering Software is an important method for digitalising public purchasing. Subsequently, literature describes that API Management Software is a part of IoT, while the interviewees consider API to be a separate technology (Elhoone, Zhang, Anwar, & Desai, 2020, p. 2841). Also, BI is not defined in the literature as a digital technology from Industry 4.0 since a different definition is used in literature and practice. Literature defines BI as "an umbrella term for technologies' techniques, tools strategies, and software systems" (Ahmad, Miskon, Alabdan, & Tlili, 2020, p. 2) whereas the research defines BI as a dashboard to analyse and improve the information basis of organisations. Additionally, Cloud Computing was not mentioned in literature since it is considered to be part of an overarching system, CPS (Kim, 2017, p. 1). Finally, OCR was not mentioned in literature since this type of software is defined as Optical Character Recognition instead of Optical Content Recognition (Debnath, Vyjayanthi, Chaitra, & Ghosh, 2020, p. 1207).

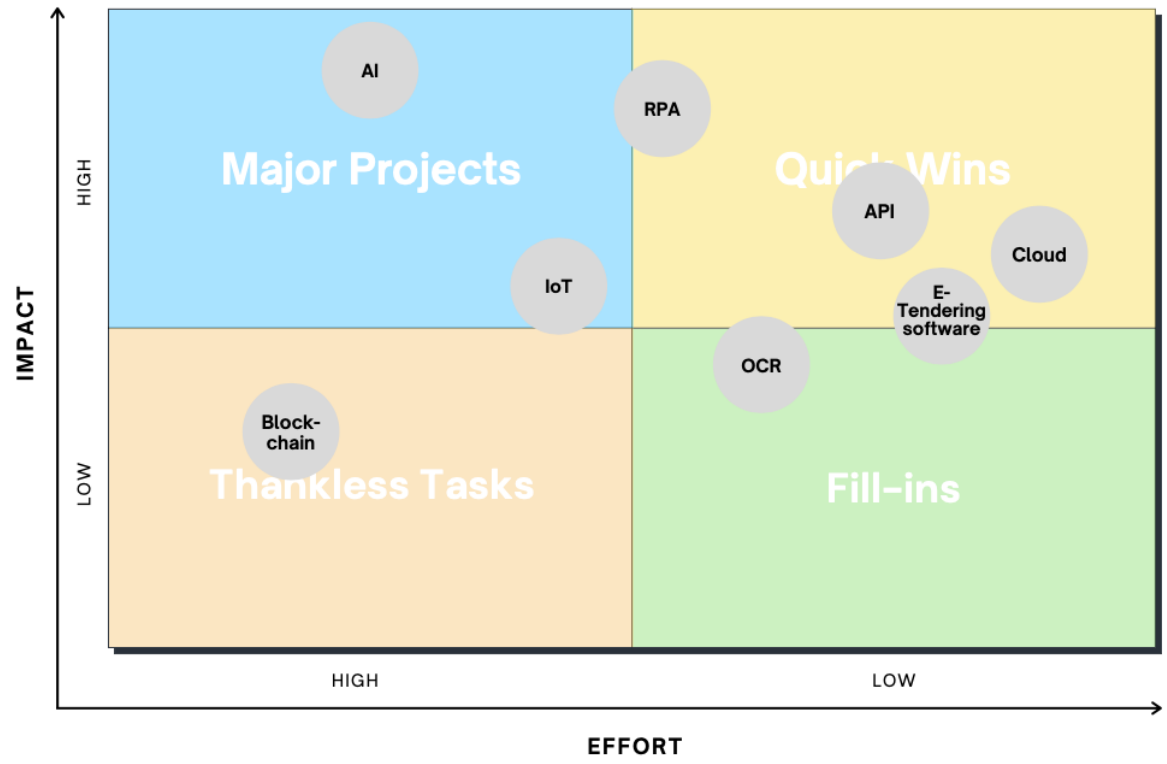
In addition, several technologies were found in literature but did not come to the attention in the interviews. First, a reason that CPS is not mentioned in the interviews can be because CPS is applied in manufacturing (Suri et al., 2017, p. 488). Therefore, this technology is not applicable in public purchasing. Another reason is that literature defines CPS as an overarching system of several technologies, IoT, Big Data, Cloud Computing, and Industry 4.0 (Kim, 2017, p. 1). Second, Digital Twins are "models that represent accurate copies of physical entities in real-time" (Schiele et al., 2021, p. 4). According to Tao, Qi, Wang, and Nee (2019), digital twins "can endow manufacturing systems with greater efficiency, resilience, and intelligence" (p. 653). Therefore, it can be concluded that Digital Twins are applicable for manufacturing organisations instead of the purchasing department of public organisations. Finally, 3D printing is mentioned in literature as an important technology from Industry 4.0. However, 3D printing was not mentioned in the interviews. The literature describes that 3D printing can help to "study common processing equipment, manufacturing, maintenance, logistics, and operations" (Chong et al., 2018, p. 1). Therefore, this technology is considered to be not applicable in the purchasing process.

5.2 Practical implications: start small but think big and expand over time

This research contributes to practice by providing an overview of the opportunities digitalisation can offer for purchasing and contract management in public organisations. According to Harkácsi and Szegfű (2021) organisations "will always fall behind the quick development of emerging new technologies, since regulators must first understand the practical functioning and risks of these technologies so that they can create adequate but not excessively restricting rules" (p. 154). Therefore, public organisations must start experimenting with digitalisation methods to avoid falling too far behind. Organisations should start small but think big and expand over time. An important starting point for public organisations to start with digitalisation is to examine processes and determine where digitalisation can reduce administrative work and increase efficiency.

To provide a clear overview of the digital technologies that can be applied in practice an impact/effort matrix (figure 12) is put together. In this overview, the digital technologies are placed in the matrix based on the effort that is needed to implement the technology and the impact the technology on the organisation has after implementation (Antony, Laux, & Cudney, 2019, p. 20). With the use of this matrix, the digital technologies can be scheduled in four groups: fill-ins; quick wins; thankless tasks; major projects.

Figure 12 Prioritising digital technologies in an effort/impact matrix



The effort/impact matrix provides an overview to guide organisations through digital transformation. To apply digital technologies in purchasing and contract management, organisations must start with solutions that require little effort but have a high impact. Therefore, as mentioned in the synthesis part, the first adoption is Cloud Computing. Working in the cloud is a condition to start with other applications. Hereafter, organisations can easily apply API connections to transfer data between systems. When programs do not have an API connection, RPA can be used to transfer data. This requires some more effort but will result in reducing administrative and time-consuming tasks. RPA can also be applied in digitalising spend analysis to retrieve real-time information. Finally, after implementing smaller successful technologies, organisations should experiment with the use of AI. AI can be applied in several processes which differ in complexity. From applying web scraping bots to retrieve market information to automatically answer questions. In conclusion, organisations should start with small applications, extend, and improve over time.

5.3 Limitations and future research: the lack of generalisability offers opportunities for future research

While conducting the research, there are always limitations that occur. The first limitation that is recognised in this research is the sample size. According to Antwi and Hamza (2015), the small number of 16 interviewees that have been conducted is limited and makes the research not entirely generalisable (p. 220). The second limitation concerns the nationality of the respondents. All respondents have Dutch nationality. Therefore, all interviews were conducted in the native language, Dutch, to achieve the most valuable information. However, it could have been valuable to learn from best practices in other countries, for example, multinationals that have already made big investments in digitalising the purchasing department (Sun & Medaglia, 2019, p. 1). Another limitation that is recognised is that this research is focused on public organisations. In other words, the use of digital technologies in purchasing and contract management activities of private organisations is not studied. However, these findings could be integrated with Srai and Lorentz (2019) who studied the digitalisation of purchasing and supply management in the private sector yet did not apply the PPM of Van Weele.

Based on these limitations, it can be concluded that it is valuable to conduct further research. First, to reduce the lack of generalisability future research must extend the number of interviewees. Also, future research can be conducted by identifying one digital technology and examining the implementation of this technology in the purchasing department of a

public organisation. This includes not only researching the possible use of the technology in public purchasing but also examining the risks, costs and method of implementation. Finally, in future research, it might be valuable to build a roadmap for organisations that want to start with the use of digital technologies in purchasing. Then organisations can determine how they can reach the highest level for their specific organisation and what time it would take.

Bibliography

Ahmad, S., Miskon, S., Alabdan, R., & Tlili, I. (2020). Towards sustainable textile and apparel industry: Exploring the role of business intelligence systems in the era of industry 4.0. *Sustainability, 12*(7), 2632.

Allal-Chérif, O., Simón-Moya, V., & Ballester, A. C. C. (2021). Intelligent purchasing: How artificial intelligence can redefine the purchasing function. *Journal of Business Research, 124*, 69-76.

Antony, J., Laux, C., & Cudney, E. (2019). Lean Six Sigma Project Selection and Prioritisation. In *The Ten Commandments of Lean Six Sigma*: Emerald Publishing Limited.

Antwi, S. K., & Hamza, K. (2015). Qualitative and quantitative research paradigms in business research: A philosophical reflection. *European journal of business and management, 7*(3), 217-225.

Arlbjørn, J. S., & Freytag, P. V. (2012). Public procurement vs private purchasing: is there any foundation for comparing and learning across the sectors? *International Journal of Public Sector Management*.

ATLAS.ti. (n.d.). What is ATLAS.ti? . Retrieved from https://atlasti.com/product/what-is-atlas-ti/

Baarda, B. (2014). Dit is onderzoek. *Handleiding voor kwantitatief en kwalitatief onderzoek*.

Bäckstrand, J., Suurmond, R., van Raaij, E., & Chen, C. (2019). Purchasing process models: Inspiration for teaching purchasing and supply management. *Journal of purchasing and supply management, 25*(5), 100577.

Balyen, L., & Peto, T. (2019). Promising artificial intelligence-machine learning-deep learning algorithms in ophthalmology. *The Asia-Pacific Journal of Ophthalmology, 8*(3), 264-272.

Braun, V., & Clarke, V. (2012). Thematic analysis.

Caldwell, N., Bakker, E., & Read, J. J. (2012). The purchasing process in public procurement. In *Public Procurement* (pp. 177-187): Routledge.

Calp, M. H. (2020). The role of artificial intelligence within the scope of digital transformation in enterprises. In *Advanced MIS and Digital Transformation for Increased Creativity and Innovation in Business* (pp. 122-146): IGI Global.

Cambridge Dictionary. (n.d.). The Industrial Revolution. Retrieved from https://dictionary.cambridge.org/dictionary/english/industrial-revolution

Chen, J. X. (2016). The evolution of computing: AlphaGo. *Computing in Science & Engineering, 18*(4), 4-7.

Chong, S., Pan, G.-T., Chin, J., Show, P. L., Yang, T. C. K., & Huang, C.-M. (2018). Integration of 3D printing and Industry 4.0 into engineering teaching. *Sustainability, 10*(11), 3960.

Dachyar, M., & Praharani, B. (2016). *Improvement of procurement business process (procure-to-pay) in Indonesian shipping company.* Paper presented at the Knowledge, Service, Tourism & Hospitality: Proceedings of the Annual International Conference on Management and Technology in Knowledge, Service, Tourism & Hospitality 2015 (SERVE 2015), Bandung, Indonesia, 1-2 August 2015.

Debnath, A., Vyjayanthi, M., Chaitra, N., & Ghosh, R. (2020). *Design and Development of OCR Integrated Automated Writing Machine.* Paper presented at the 2020 Third International Conference on Smart Systems and Inventive Technology (ICSSIT).

Deloitte. (2020a). *AI Procurement in a Box: AI Government Procurement Guidelines*. Retrieved from https://www2.deloitte.com/content/dam/Deloitte/global/Documents/About-Deloitte/gx-wef-ai-government-procurement-guidelines-2020.pdf

Deloitte. (2020b). Government Trends 2020. Retrieved from https://www2.deloitte.com/us/en/insights/industry/public-sector/government-trends/2020/government-data-ai-ethics.html

Denscombe, M. (2012). *Research proposals: A practical guide: A practical guide*: McGraw-Hill Education (UK).

Efendigil, T., Önüt, S., & Kahraman, C. (2009). A decision support system for demand forecasting with artificial neural networks and neuro-fuzzy models: A comparative analysis. *Expert Systems with Applications, 36*(3), 6697-6707.

El Sawy, O. A., Malhotra, A., Park, Y., & Pavlou, P. A. (2010). Research commentary—seeking the configurations of digital ecodynamics: It takes three to tango. *Information systems research, 21*(4), 835-848.

Elhoone, H., Zhang, T., Anwar, M., & Desai, S. (2020). Cyber-based design for additive manufacturing using artificial neural networks for Industry 4.0. *International Journal of Production Research, 58*(9), 2841-2861.

Engineering and Physical Sciences Research Council. (n.d.). Artificial intelligence technologies. Retrieved from https://epsrc.ukri.org/research/ourportfolio/researchareas/ait/

Erridge, A. (2007). Public procurement, public value and the Northern Ireland unemployment pilot project. *Public Administration, 85*(4), 1023-1043.

Gelderman, C. J., & Albronda, B. (2013). *Professioneel inkopen* (4 ed.): Noordhoff Uitgevers.

Goyal, M. (2018). Let's get Internet of Things (IoT) Ready for Procurement! . Retrieved from https://www.zycus.com/blog/procurement-technology/lets-get-internet-of-things-iot-ready-for-procurement.html#:~:text=For%20Procurement%20particularly%2C%20IoT%20works,to%20make%20better%2Dinformed%20decisions.

Greenwood, J. (1999). The Third Industrial Revolution: Technology, Productivity and Income Inequality, AEI Studies on Understanding Inequality. In: Washington, DC. The AEI Press. Also, printed in the Economic Review.

Haenlein, M., & Kaplan, A. (2019). A brief history of artificial intelligence: On the past, present, and future of artificial intelligence. *California management review, 61*(4), 5-14.

Harkácsi, G. J., & Szegfű, L. P. (2021). The Role of the Compliance Function in the Financial Sector in the Age of Digitalisation, Artificial Intelligence and Robotisation. *Financial and Economic Review, 20*(1), 152-170.

Hwang, J. S. (2016). The fourth industrial revolution (industry 4.0): intelligent manufacturing. *SMT Magazine, 3*, 616-630.

IBM. (2020). Artificial intelligence (AI). Retrieved from https://www.ibm.com/cloud/learn/what-is-artificial-intelligence

IBM. (n.d.). IBM Deep Blue. Retrieved from https://www.ibm.com/ibm/history/ibm100/us/en/icons/deepblue/

International Telecommunication Union. (2012). Internet of Things Global Standards Initiative. Retrieved from https://www.itu.int/en/ITU-T/gsi/iot/Pages/default.aspx

Jamshed, S. (2014). Qualitative research method-interviewing and observation. *Journal of basic and clinical pharmacy, 5*(4), 87.

Janicke, M., & Jacob, K. (2013). A third industrial revolution. *Long-term governance for social-ecological change*, 47-71.

Keck, M., Connaughton, P., & Sommers, K. (2020). Hype Cycle for Procurement and Sourcing Solutions. *Gartner*.

Keswani, G. G. (2013). Artificial Intelligence-Is Our Future Bright or Bleak. *International Journal of Engineering and Advanced Technology (IJEAT) ISSN*, 2249-8958.

Khan, R. N. (1987). The 3rd industrial revolution: an economic overview *Impact of Science on Society, 37*(2), 115-122.

Kim, J. H. (2017). A review of cyber-physical system research relevant to the emerging IT trends: industry 4.0, IoT, big data, and cloud computing. *Journal of industrial integration and management, 2*(03), 1750011.

Knight, L., Harland, C., Telgen, J., Thai, K. V., Callender, G., & McKen, K. (2012). *Public procurement: International cases and commentary*: Routledge.

Kumar, V., Ramachandran, D., & Kumar, B. (2021). Influence of new-age technologies on marketing: A research agenda. *Journal of Business Research, 125*, 864-877.

Lee, J., Bagheri, B., & Kao, H.-A. (2015). A cyber-physical systems architecture for industry 4.0-based manufacturing systems. *Manufacturing letters, 3*, 18-23.

Lewis, T. (2014). A Brief History of Artificial Intelligence. Retrieved from https://www.livescience.com/49007-history-of-artificial-intelligence.html

Loureiro, S. M. C., Guerreiro, J., & Tussyadiah, I. (2020). Artificial intelligence in business: State of the art and future research agenda. *Journal of Business Research*.

Magaldi, D., & Berler, M. (2020). Semi-structured interviews. *Encyclopedia of personality and individual differences*, 4825-4830.

Min, H. (2010). Artificial intelligence in supply chain management: theory and applications. *International Journal of Logistics: Research and Applications, 13*(1), 13-39.

Mulder, L. (2019). De impact van Artificial Intelligence op inkoop. *Qando*.

Murphy, K., Di Ruggiero, E., Upshur, R., Willison, D. J., Malhotra, N., Cai, J. C., . . . Gibson, J. (2021). Artificial intelligence for good health: a scoping review of the ethics literature. *BMC medical ethics, 22*(1), 1-17.

Murray, J. G. (1999). Local government demands more from purchasing. *European Journal of Purchasing & Supply Management, 5*(1), 33-42.

NEVI. (2018). *Inkoop & Blockchain*. Retrieved from https://nevi.nl/inkoop/whitepapers/inkoop-blockchain-perfect-match

Ocampo, L. A., Abad, G. K. M., Cabusas, K. G. L., Padon, M. L. A., & Sevilla, N. C. (2018). Recent approaches to supplier selection: a review of literature within 2006-2016. *International Journal of Integrated Supply Management, 12*(1-2), 22-68.

Ongsulee, P. (2017). *Artificial intelligence, machine learning and deep learning.* Paper presented at the 2017 15th International Conference on ICT and Knowledge Engineering (ICT&KE).

Oppermann, A. (2019). Artificial Intelligence vs. Machine Learning vs. Deep Learning. Retrieved from https://towardsdatascience.com/artificial-intelligence-vs-machine-learning-vs-deep-learning-2210ba8cc4ac

Patten, M. L., & Newhart, M. (2017). *Understanding research methods: An overview of the essentials*: Routledge.

Perez, C. (2010). Technological revolutions and techno-economic paradigms. *Cambridge journal of economics, 34*(1), 185-202.

Prisecaru, P. (2016). Challenges of the fourth industrial revolution. *Knowledge Horizons. Economics, 8*(1), 57.

Pūraitė, A., Adamonienė, R., & Žemeckė, A. (2020). Sustainable Digitalization in Public Institutions: Challenges for Human Rights. *European Journal of Sustainable Development, 9*(3), 91-91.

Queirós, A., Faria, D., & Almeida, F. (2017). Strengths and limitations of qualitative and quantitative research methods. *European Journal of Education Studies*.

Rados, D. L. (1970). Some aspects of small firm purchasing activities. *European Journal of Marketing*.

RMIT University Australia. (n.d.). What are cyber-physical systems?
. Retrieved from https://www.rmit.edu.au/news/c4de/what-are-cyber-physical-systems

Russell, S., & Norvig, P. (2002). Artificial intelligence: a modern approach.

Salkin, C., Oner, M., Ustundag, A., & Cevikcan, E. (2017). A conceptual framework for Industry 4.0. In *Industry 4.0: Managing the Digital Transformation* (pp. 5-6): Springer.

Schiele, H. (2016). Industrie 4.0 in der Beschaffung. Retrieved from https://diglib.tugraz.at/download.php?id=585234c1bf28d&location=browse

Schiele, H. (2019). Purchasing and supply management. In *Operations, logistics and supply chain management* (pp. 45-73): Springer.

Schiele, H., Bos-Nehles, A., Delke, V., Stegmaier, P., & Torn, R.-J. (2021). Interpreting the industry 4.0 future: technology, business, society and people. *Journal of Business Strategy*.

Schiele, H., & Torn, I. A. R.-J. (2019). Cyber-physical systems with autonomous machine-to-machine communication: Industry 4.0 and its potential for purchasing and supply management. *International Journal of Procurement Management*.

Schiereck, P. (2021). *Purchasing Complex Services–Possibilities and Chances through Industry 4.0.* University of Twente,

Schuh, G., Potente, T., Varandani, R., Hausberg, C., & Fränken, B. (2014). Collaboration moves productivity to the next level. *Procedia Cirp, 17*, 3-8.

Schwab, K. (2015). The Fourth Industrial Revolution. Retrieved from https://www.foreignaffairs.com/articles/2015-12-12/fourth-industrial-revolution

Senyo, P. K., Effah, J., & Osabutey, E. L. (2021). Digital platformisation as public sector transformation strategy: A case of Ghana's paperless port. *Technological Forecasting and Social Change, 162*, 120387.

Srai, J. S., & Lorentz, H. (2019). Developing design principles for the digitalisation of purchasing and supply management. *Journal of purchasing and supply management, 25*(1), 78-98.

Sun, T. Q., & Medaglia, R. (2019). Mapping the challenges of Artificial Intelligence in the public sector: Evidence from public healthcare. *Government Information Quarterly, 36*(2), 368-383.

Suri, K., Cuccuru, A., Cadavid, J., Gerard, S., Gaaloul, W., & Tata, S. (2017). *Model-based Development of Modular Complex Systems for Accomplishing System Integration for Industry 4.0.* Paper presented at the MODELSWARD.

Syed, R., Suriadi, S., Adams, M., Bandara, W., Leemans, S. J., Ouyang, C., . . . Reijers, H. A. (2020). Robotic process automation: contemporary themes and challenges. *Computers in Industry, 115*, 103162.

Talhaoui, A., & Mulder, L. (2019). Artificial Intelligence voor inkoop. *Qando*.

Tao, F., Qi, Q., Wang, L., & Nee, A. (2019). Digital twins and cyber–physical systems toward smart manufacturing and industry 4.0: Correlation and comparison. *Engineering, 5*(4), 653-661.

Telgen, J., Harland, C., & Knight, L. (2012). *Public procurement: International cases and commentary*: Routledge.

Tieman, M., & Ghazali, M. C. (2013). Principles in halal purchasing. *Journal of Islamic Marketing*.

Tokmakov, M. (2020). *Artificial Intelligence in Corporate Governance.* Paper presented at the International Online Forum named after A. Ya. Kibanov" Innovative Personnel Management".

Toorajipour, R., Sohrabpour, V., Nazarpour, A., Oghazi, P., & Fischl, M. (2021). Artificial intelligence in supply chain management: A systematic literature review. *Journal of Business Research, 122*, 502-517.

Torn, I. A. R.-J. (2017). *The future of purchasing and industry 4.0: how purchasing can progress and benefit the fourth industrial revolution.* University of Twente,

Torn, I. A. R.-J., Pulles, N., & Schiele, H. (2018). *Industry 4.0 and how purchasing can progress and benefit from the fourth industrial revolution.* Paper presented at the 27th Annual IPSERA Conference.

Turing, A. (1950). *Computing machinery and intelligence*: MIT Press Cambridge, MA.

Umbenhauer, B., & Gregson, J. (2016). The Deloitte Global CPO Survey 2016.

Umbenhauer, B., & Younger, L. (2018). Deloitte CPO survey.

Vaidya, K., Sajeev, A., & Callender, G. (2006). Critical factors that influence e-procurement implementation success in the public sector. *Journal of Public Procurement*.

Van der Valk, W., & Rozemeijer, F. (2009). Buying business services: towards a structured service purchasing process. *Journal of Services Marketing*.

van Ooijen, P. M. (2019). Quality and curation of medical images and data. In *Artificial intelligence in medical imaging* (pp. 247-255): Springer.

Verhoeven, N. (2011). *Doing research: The hows and whys of applied research*: Lyceum Books Incorporated.

Verhoeven, N. (2016). *Wat is onderzoek* (5 ed.). Amsterdam: Boom Lemma Uitgevers.

Wang, L., & Wang, G. (2016). Big data in cyber-physical systems, digital manufacturing and industry 4.0. *International Journal of Engineering and Manufacturing (IJEM), 6*(4), 1-8.

Weissbarth, R., Geissbauer, R., & Wetzstein, J. (2016). *Procurement 4.0: Are you ready for the digital revolution?* Retrieved from

Woiceshyn, J., & Daellenbach, U. (2018). Evaluating inductive vs deductive research in management studies: Implications for authors, editors, and reviewers. *Qualitative Research in Organizations and Management: An International Journal*.

Xu, M., David, J. M., & Kim, S. H. (2018). The fourth industrial revolution: Opportunities and challenges. *International journal of financial research, 9*(2), 90-95.

Zijm, H. (2019). Manufacturing Systems. In *Operations, Logistics and Supply Chain Management* (pp. 75-96): Springer.

Appendixes

Appendix I – Interviewguide

Introduction

Each interview will start with some small talk, in which gratitude will be shown to the participant for cooperating to this research. Subsequently, I will introduce myself and give information about the purpose of this research. Hereafter, the estimated duration of the interview is indicated, and it is made clear that there is sufficient room for the respondent's own input. Finally, the respondent will be asked if there are any questions beforehand, if not, the interview will start, and the respondent will introduce himself.

Introduction	
Subject	**Explanation**
Small talk	Welcome and thank you for the opportunity to conduct an interview.
Approval	The information from this interview will be used exclusively for this research and the recording will be deleted afterwards. Can I use your name in the survey or would you prefer to keep this anonymous? Do you approve me to record the interview? Agree: start recording.
Introduction	Alicia Weenink, 23 years old, Master student Business Administration with a specialization in purchasing and supply management on the University of Twente.
Research goal	The goal of this research is to give public organisations, insight in how Artificial Intelligence (or when this is not applicable, another form of digitalisation) could be used within the purchasing department.
Estimated time	The interview will take approximately 45 minutes. I have drawn up a number of questions for the interview, but there is also room for personal input.
Questions	Does the respondent have any questions beforehand? If not, start with the interview.

Conclusion

The conclusion of each interview will take place in the same way. First of all, the end of the interview is indicated, followed by a short summary. Subsequently, the respondent is asked if there are any additions to the summary. If this is not the case, the respondent will be thanked for cooperating and it will be indicated that questions may be asked later via email. Finally, the interview will be ended.

Conclusion	
Subject	**Explanation**
Ending	The end of the interview is announced.
Summary	The interview is briefly summarised.
Check	Check whether summary is correct.
Additions	Ask whether the respondent has any additions to the summary.
Thank	Thank respondent for cooperating.
Contact	Ask contact details and ask whether the respondent has any questions as a result of the interview.
Conclusion	Exit and stop recording.

Interviewguide: Experts		
Topic	**Question**	**Aspects**
Introduction	Could you introduce yourself?	Name Age Organisation Function Experience
Experience	Do you have experience of working in an organisation that used digital technologies within purchasing?	
Knowledge	How do you collect knowledge about the use of digital technologies within purchasing (in public organisations)?	Suppliers Academic research Experience
Trends and developments	What are current trends and developments of the digitalisation of purchasing (in public organisations)?	Future Innovation
Purchasing process (Van Weele)	How could digital technologies be used in the purchasing process in public organisations?	Specification Selecting Contracting Ordering Expediting and evaluation Follow-up/evaluation
Improvements	What might be the biggest improvement to increase the efficiency and effectivity of the purchasing department of a public organisation? What might be the biggest improvement to increase the value of the purchasing department of a public organisation?	Costs Benefit Savings Suppliers Sustainability
Recommendations	Do you have any suggestions of organisations I can contact who make use of digital technologies (Artificial Intelligence) in purchasing?	Public organisations Private organisations

	Do you have any additions or recommendations that I can use in my research?	
When time left		
Ambition	What ambitions of organisations do you find in the digitalisation of purchasing?	Artificial Intelligence Internet of Things Cyber-Physical Systems Blockchain Digital Twins 3D printing Robotic Process Automatisation

Interviewguide: Public organisations		
Topic	**Question**	**Aspects**
Introduction	Could you introduce yourself?	Name Age Organisation Function
Ambition	What is the ambition of your organisation in regard to the use of digital technologies? What is the ambition of your organisation in regard to the use of digital technologies in purchasing? Why did you/your organisation started to use digital technologies within purchasing? How does the use of digital technologies within purchasing fit in the corporate strategy of your organisation? Does your organisation have concrete targets regarding digitalisation in purchasing on short and long term?	Artificial Intelligence Internet of Things Cyber-Physical Systems Blockchain Digital Twins 3D printing Robotic Process Automatisation Experiences Costs Laws and regulations Efficiency Future Innovation Efficiency Short term Long term
Knowledge	How did your organisation collect knowledge about the use of digital technologies within purchasing? Is this knowledge being spread around the entire organisation?	Suppliers Customers Trainings Intranet Meetings
Trends and developments	How do you keep track of new trends and developments about digital technologies within purchasing?	Suppliers Customers Trainings

	Do you have examples of how you react on new trends and developments?	
Purchasing process (Van Weele)	How could digital technologies be used in the purchasing process in public organisations?	Specification Selecting Contracting Ordering Expediting and evaluation Follow-up/evaluation
Reflection	How do you look back to your organisation and the way they use digital technologies in purchasing?	Unexpected things Experience Image of the organisation
Recommendations	Do you have any additions or recommendations that I can use in my research?	
When time left		
Financial	Which financial consequences does the use of digital technologies within purchasing have?	Costs Workforce Savings

Appendix II - The difference between public and private organisations

Compared to the private sector, public organisations are concerned with matters such as legitimacy and efficiency (I. 5, 9, 10, 11, 13). Data security is an important topic which forces organisations to make careful considerations about the application of digital technologies (I. 4, 13). However, the focus on data security can also obstruct the development of digitalisation to improve efficiency and effectiveness in the organisation (I. 9, 13).

In 2012 the EU has published a law that forces public organisations to digitalise all source-to-contract activities to prevent fraud and increase transparency and objective non-discriminatory purchasing (I. 3, 5, 8, 9). According to interviewee 1, this law leads to having a higher degree of digital technologies compared to profit organisations. However, on the other hand, the adoption of digitalisation is lower since public organisations are less likely to experiment, practice, and switch software. Nevertheless, private organisations are not forced to digitalise the source-to-contract activities. Private organisations are more intrinsically motivated to digitalise purchasing activities which might lead to a more successful application (I. 1). Besides, the law only focuses on digitalising the source-to-contract activities. Therefore, purchase-to-pay activities are often not digitalised (I. 3). In addition, private organisations are more goal-oriented and base decisions on achieving a positive result (I. 8).

Public purchasing can be considered as more complex, compared to private organisations. For example, public organisations purchase very diverse products and services and need to take into account multiple interests (I .11). Also, the entire decision-making process can be considered more complex in public organisations (I. 9). In addition, public purchasing must consider greater risk, compared to private organisations. After publishing a tender, adjustments cannot be made. While private organisations can still make adjustments for example in specifications or weights for criteria after the tender is published (I. 6).

Concerning digitalisation, public organisations are often seen as conservative (I. 4). Most public organisations stay behind in the application of digital technologies compared to private organisations (I. 8). Overall, many public organisations have a lack knowledge of the opportunities digitalisation has and are hesitant to try new things. Also, public organisations often have difficulties adopting software, while private organisations more easily experiment with new trends. Public organisations often purchase safe, proven technologies instead of new innovative ones (I. 4). While profit organisations are more progressive and apply new

technologies quickly (I. 5). Also, the private sector is considered progressive in the area of digitalisation (I. 11). The entire purchasing process and decision-making are faster, compared to public organisations (I. 11). Private organisations embrace certain developments faster and more easily and dare to take higher risks (I. 5, 11). However, when an organisation is correctly digitalised, public and private organisations do not show many differences (I. 6).

Also, according to interviewee 8, between public organisations, there is a big difference in culture and the way in which digitalisation is handled. The national government, for example, experiments with the use of new digital technologies, while smaller public organisations use proven technologies and will not experiment easily (I. 8, 16). Also, some technologies are just not appropriate for small public organisations because the costs do not outweigh the benefits (I. 8). But overall, the experience with digitalisation is limited within public organisations (I. 9).

Compared to public organisations, many private organisations have already included digitalisation within spend analysis (I. 1). Public organisations mainly use excel to create spend analyses (I. 1). This requires a lot of manual work, which makes it suitable for digitalisation (I. 3). An example of digitalising spend analysis is to create a connection with invoices or the purchase-to-pay system. This will provide the organisation with real-time information (I. 4, 9). However, as stated before, especially within public organisations this is often not applied. Digitalising spend analysis must be one of the first steps an organisation should apply in their roadmap to becoming a digital organisation (I. 8, 15). Having real-time information from a spend analysis might lead to cost savings (I. 8). On the contrary, big private organisations have often digitalised the spend analysis which increases efficiency and provides real-time spend information on a supplier (I. 1, 9).

Table 14 Comparison of private and public organisations

	Private organisation	**Public organisation**
Legislation	Goal-oriented, focussed on reaching a positive result. Intrinsically motivated to digitalise source-to-contract activities which leads to a successful application.	Concerned with legitimacy and efficiency matters. Forced to digitalise all source-to-contract activities to prevent fraud and increase transparency and objective non-discriminatory purchasing.
Complexity	Less complex decision-making process. Able to make adjustments after publishing a tender.	Complex by taking into account multiple interests and having greater risks. Not able to make adjustments after publishing a tender. Complex decision-making process.
Digitalisation	Easily experiment with new trends regarding digitalisation and dare to take higher risks.	Considered conservative. Often purchase safe and proven technologies instead of innovative ones.

Appendix III - The context of purchasing in a public organisation

Purchasing is about fulfilling buying needs which can be done with the use of software (I. 1). According to interviewee 1, purchasing is seen as a complicated department to get things done. However, purchasing must make life easier, not more complicated (I. 8).

To make improvements in the purchasing department, the purchasing strategy must be directly derived from the organisational strategy (I. 3). The purchasing department must have the same goals and procedures as the organisation (I. 3, 16). Also, purchasing is usually not independently represented within a board of directors or a management team (I. 8). This could be an explanation why purchasing is still very conservative.

Overall, purchasing staff needs to be aware to not fall too far behind (I. 9). According to interviewee 9, the experience with digital technologies is limited. However, more organisations start to add intelligence within purchasing and its suppliers. Nevertheless, most (public) organisations do not apply new digital technologies until the central government forces them (I. 9). Also, public purchasers are often busy and do not have time to spend on researching how the purchasing process can be improved. Subsequently, within public purchasing, there is a tension between efficiency and legitimacy (I. 11, 13). Sometimes, something is efficient but not lawful or the other way around. Therefore, it is important to find the right balance between these two topics and the role purchasers have (I. 11).

The purchasing function is an administrative function where profit can be made by including digitalisation (I. 9). Therefore, especially within private organisations, several digital technologies can be used to reduce the number of administrative tasks (I. 1, 9). This gives employees more time to improve the purchasing process, from requests for proposals (RFP's) to supplier conversations and sustainability (I. 1, 13). And finally, digitalisation can lead to the same amount of work but with fewer employees (I. 13).

The digitalisation of old processes does not fundamentally change the way organisations do business with each other (I. 5). The real transformation in digitalisation is not in making old processes more efficient, but to using a new way of approaching the market: the creation of marketplaces (I. 1, 5). According to interviewee 5, marketplaces have been used for a long time within the business-to-consumer market. For example, to book a room in a hotel. However, in the business-to-business market, this is new (I. 5). Experts consider this to be the future, however, within the United States, big forerunner organisations have slowly started applying this (I. 1). Interviewee 1 states that with the use of a marketplace suppliers are thoroughly checked to maintain trust. The best suppliers in the market are then known and certified. Based on specific filters, purchasers can a few potential

suppliers that are allowed to send a quotation. The buyer selects a supplier based on a transparent overview of prices and reviews on the marketplace, instead of publishing an open tender and receiving multiple quotations. The marketplace must be applicable for both the purchasing of products and services (I. 1). However, to be able to use marketplaces in the future, laws and regulations must be changed, in a way that purchasing is still transparent and gives equal opportunities (I. 5). It is expected that this will lead to big changes and increased efficiency in the future (I. 1, 5).