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Supply Chain Management

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AUTOMATED PURCHASE TO PAY PROCESS VALUE MODELING AND COMPARATIVE PROCESS SPEEDS

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ABSTRACT

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The importance of efficient supply chain management has increased due to globalization and the blurring of organizational boundaries. Various supply chain management technologies have been identified to drive organizational profitability and financial performance. Organizations have historically been concentrating heavily on the flow of goods and services, while less attention has been dedicated to the flow of money. While supply chains are becoming more transparent and automated, new opportunities for financial supply chain management have emerged through information technology solutions and comprehensive financial supply chain management strategies.

This research concentrates on the end part of the purchasing process which is the handling of invoices. Efficient invoice processing can have an impact on organizations working capital management and thus provide companies with better readiness to face the challenges related to cash management. Leveraging a process mining solution the aim of this research was to examine the automated invoice handling process of four different organizations. The invoice data was collected from each organizations invoice processing system. The sample included all the

invoices organizations had processed during the year 2012. The main objective was to find out whether e-invoices are faster to process in an automated invoice processing solution than scanned invoices (post entry into invoice processing solution). Other objectives included looking into the longest lead times between process steps and the impact of manual process steps on cycle time. Processing of invoices from maverick purchases was also examined. Based on the results of the research and previous literature on the subject, suggestions for improving the process were proposed.

The results of the research indicate that scanned invoices were processed faster than e-invoices. This is mostly due to the more complex processing of e-invoices. It should be noted however that the manual tasks related to turning a paper invoice into electronic format through scanning are ignored in this research. The transitions with the longest lead times in the invoice handling process included both pre-automated steps as well as manual steps performed by humans. When the most common manual steps were examined in more detail, it was clear that these steps had a prolonging impact on the process. Regarding invoices from maverick purchases the evidence shows that these invoices were slower to process than invoices from purchases conducted through e-procurement systems and from preferred suppliers. Suggestions on how to improve the process included: increasing invoice matching, reducing of manual steps and leveraging of different value added services such as invoice validation service, mobile solutions and supply chain financing services. For companies that have already reaped all the process efficiencies the next step is to engage in collaborative financial supply chain management strategies that can benefit the whole supply chain.

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Globalisaatio ja organisaatioiden rajojen hämärtyminen ovat vaikuttaneet siihen, että tehokas toimitusketjun johtaminen yrityksissä on yhä tärkeämpää. Lukuisten toimitusketjun johtamiseen tarkoitettujen informaatioteknologiaratkaisujen on havaittu tehostavan yritysten kannattavuutta ja taloudellista suorituskykyä. Historiallisesti yritykset ovat keskittyneet tehostamaan tuotteiden ja palvelujen virtausta organisaatioiden välillä, kun taas rahan virtaus on jäänyt vähemmälle huomiolle. Toimitusketjujen kehittyessä yhä läpinäkyvämmiksi ja automaation lisääntyessä, uudet mahdollisuudet taloudellisen toimitusketjun johtamiseen ovat lisääntyneet. Näitä ovat esimerkiksi erilaiset informaatioteknologiaratkaisut ja kokonaisvaltaiset taloudellisen toimitusketjun johtamiseen keskittyvät strategiat.

Tämä tutkimus keskittyy hankintaprosessin loppupäähän, tarkemmin ottaen ostolaskujen käsittelyyn. Tehokkaalla laskunkäsittelyllä voidaan vaikuttaa organisaation käyttöpääoman hallintaan, joka luo organisaatioille

paremmat valmiudet kohdata kassanhallintaan liittyviä haasteita. Hyödyntämällä prosessinmallinnustyökalua tämä tutkimus tarkastelee neljän eri yrityksen automatisoitua laskunkäsittelyprosessia. Laskudata kerättiin yritysten laskunkäsittelyjärjestelmästä ja otos sisältää jokaisen yritysten käsittelemän laskun vuoden 2012 aikana. Tutkimuksen keskiössä oli selvittää ovatko e-laskut nopeampia käsitellä kuin skannatut laskut. Lisäksi tarkoituksena oli selvittää, mitkä ovat eniten aikaa vievät prosessin vaiheet ja millainen vaikutus manuaalisilla vaiheilla on läpimenoaikoihin. Tutkimuksessa tarkastellaan myös, miten maverick-ostoista tulevien laskujen käsittely eroaa normaalien käytäntöjen mukaan ostetuiden hyödykkeiden laskuista. Perustuen tutkimukseen tuloksiin ja akateemiseen kirjallisuuteen suosituksia prosessin kehittämiseen on ehdotettu.

Tutkimuksen tulokset osoittavat, että skannatut laskut käsitellään nopeammin kuin e-laskut. Tämä johtuu suurimmaksi osaksi e-laskujen käsittelyprosessin monimutkaisuudesta. Tämä tutkimus ei kuitenkaan huomioi vaadittavia manuaalisia toimia, jotka suoritetaan ennen kuin paperilasku saadaan muutetuksi elektroniseen formaattiin. Eniten aikaa vievät prosessin vaiheet sisälsivät sekä automatisoituja vaiheita, että manuaalisia, ihmisten suorittamia vaiheita. Kun tavallisimpia manuaalisia vaiheita tarkasteltiin yksityiskohtaisemmin, tuloksista voidaan huomata, että niillä on hidastava vaikutus prosessin läpimenoaikoihin. Maverick-ostoista johtuvien laskujen käsittely oli suurimmilta osin hitaampaa kuin laskujen, jotka liittyivät hyväksyttyjen kanavien kautta tehtyihin hankintoihin. Prosessin kehittämiseksi suositellaan laskujen täsmäytyksen lisäämistä, manuaalisten vaiheiden karsimista ja kolmansien osapuolien tarjoamien lisäarvopalvelujen hyödyntämistä, näitä ovat esimerkiksi laskujen validointipalvelu, mobiilit ratkaisut ja toimitusketjun rahoituspalvelut. Yrityksille, joiden prosessi on jo tarpeeksi kypsässä vaiheessa, seuraava askel tehokkuuksien etsimiseksi piilee kokonaisvaltaisissa taloudellisen toimitusketjun johtamisen strategioissa, jotka hyödyttävät koko toimitusketjua.

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Espoo, 13.5.2013 Viljami Vanjoki

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1. INTRODUCTION

Globalization, outsourcing and the development of information technology are blurring organizational boundaries (Das & Teng 2002). Organizations are not stand alone anymore and they need to operate and interact in variety of forms within a complex global network of collaborating entities (Sayah & Zhang 2005). In this networked economy organizations focus on alliances, partnerships and collaborations, where information sharing and knowledge are considered as a source of competitive advantage. Within the context of supply chain management, collaboration and technological development, collaborative tools, automated processes, and social network phenomena are transforming society and markets and generating new working practices (Costa & Tavares 2012).

While organizations are concentrating on their core competencies, they are getting increasingly dependent on their supply chain partners for complementary activities (Schubert & Legner 2011). The application of web technologies to support procurement transactions has led to substantial growth in Internet-based supply management systems and as electronic linkages between suppliers and buyers continue to grow, business-to-business electronic commerce has been rapidly growing all over the world (Lee et. al. 2003; Kauffman & Mohtadi 2004). Today e-business already covers a wide range of different electronic services that have led to dematerialization of internal business processes, but also, to emphasize new collaborative processes between organizations (Costa & Tavares 2012). Despite the potential of supply chain management technologies and the suggestion that supply chain management technology has a more direct link to firm profitability and financial performance than many other technologies, relatively few companies have utilized inter-organizational network settings to drive financial performance in a collaborative way (Simatupang & Sridharan 2005; Blankley 2008).

Financial information and flow of money between and within organizations are essential in supply chain management (Sugirin 2009). Financial information is used in a variety of different purposes related to supply chain management such as evaluating suppliers and forecasting (Doxley 2012; Leng & Zailani 2012). Even though the financial information has been recognized as an important part of managing supply chain operations Fairchild (2005) has argued that while “supply chains are becoming more automated, providing transparency, increasing visibility, and enabling the ability to scale, the equivalent financial activities have not moved at the same speed”. While transactions between organizations usually involve a large amount of information to be processed and communication between trading partners, supply chain management is well suited for information technology support and automation through all steps of a transaction from purchasing to paying (Kim & Shunk 2004).

The aim of this research is to examine organizations purchase to pay (P2P) process and whether e-invoices are processed faster in an automated invoice processing solution than scanned invoices. The research also looks into how the processing of invoices from maverick purchases differs from the processing of invoices that are received from purchases made through appropriate channels.

The research question is as follows:

- ***Are e-invoices faster to process than scanned invoices?***

The sub questions are:

- ***Which transitions from one process step to another have the longest lead times and what kind of an impact do the manual process steps have on cycle times?***
- ***Are invoices with order or / and contract number faster to process than invoices from maverick purchases?***
- ***What kind of options organizations have to enhance the process and gain more value out of it?***

This research concentrates on examining an organizations purchase to pay process in order to identify bottlenecks and opportunities for enhancements. Comparing the processing of e-invoices and scanned invoices is at the center of this research. It should be noted however that this research only recognizes the time an invoice spends in the automated invoice processing solution. Manual tasks related to the transforming of a paper invoice into electronic format are excluded from the scope of this research. The research also examines how maverick purchases impact the processing of invoices, while providing suggestions for process enhancements based on academic literature and the current condition of the purchase to pay process of each case company.

The research is written as follows. First the author presents a short review of related literature, which is followed by the theoretical framework of the thesis. Theoretical part concentrates on purchase to pay process, collaboration and the financial aspects of supply chain management. It also encompasses the effects of automation on purchase to pay process and presents some of the basic techniques related to supply chain financing and working capital optimization. After the theoretical examination the research methods are presented as well as information on how the data for the research was collected and analyzed. The next chapter introduces the results of the research, which are examined in more detail in the following discussion chapter. The last parts of the research conclude the findings and provide answers to the research question and its sub questions, while also giving implications for further research.

2. LITERATURE REVIEW

Internet has had revolutionary effects on how organizations do business (Sayah & Zhang 2005; Puschmann & Alt 2005; Walters 2008). The literature related to supply chain management and electronic systems has been growing during the recent decades (Subramaniam & Shaw 2004; Iyer et. al. 2009). The first studies concentrated on electronic data interchange (EDI) networks mostly exploited by large corporations. It has been said that EDI networks represent the first phase of business-to-business electronic commerce in many industries (Lee et. al. 2003; Fairchild 2005). From EDI organizations have progressed towards web-based solutions that have the ability automate most of the routine processes in supply chain management for example in purchasing and accounting (Kim & Shunk 2004; Downing 2010). The latest trends in business-to-business electronic systems are cloud-based collaborative solutions that enable organizations to operate without boundaries and collaborate with their business partners (Marquez et. al. 2004; Downing 2010).

The general notion among academics is that the purchasing department can have a very large impact on organizations bottom-line (Amitt & Zott 2001; Davila et. al. 2003; Piotrowicz & Irani 2010). There are many academics that support the efficiency benefits supply chain automation can create (Croom & Johnston 2003; Attaran & Attaran 2000), but there is also controversy (Davis-Sramek et al. 2010; Smart 2010; Agan 2011) regarding information technology solutions and potential benefits. There is a variety of research within purchasing and procurement that has concentrated on the process of acquiring goods and services from several different angles (Subramaniam & Shaw 2004; van der Valk 2009). Usually closer examination of the end of the process, the actual paying for the goods has been left out the scope of many studies. The three departments that work very closely during the purchasing process are procurement, production and accounts payable (Leng & Zailani 2012; ScottMadden

2012). The link between procurement and production is a widely researched area especially in the context of lean production (Chen & Sarker 2010; Agus & Hajinoor 2012), but very limited research can be found on the collaboration of procurement and accounts payable (AP) departments.

With the growing opportunities that information technology solutions have brought for organizations, the globalization and ease of communication have changed the way organizations go about their business (Lee et. al. 2003; Chong et. al. 2009). Collaborating within a network of individual entities has been increasing and many academics have been interested by the opportunities enabled by collaboration (Min et. al. 2005; Cao & Zhang 2011). Sayah and Zhang (2005) have studied the enablement of collaboration through web technologies, Walters (2008) on the other hand identified that Internet technologies can drive competitive advantage in collaborating supply chains.

Most of the academic literature related to supply chain management has focused on the movement of goods and services, but very few concentrate on the movement of money (Fairchild, 2005). The flow of money has raised the interest of academics during the 21st century and is slowly increasing its position as a research area (Camerinelli 2009; Sugirin 2009). The application of information technology solutions in the procurement and accounting fields has prompted the interest of financial aspects in the supply chain. The areas that have most research in financial supply chain management are supply chain financing (Sugirin 2009) and working capital optimization. Working capital and cash to cash cycles have been researched for example by Farris II & Hutchison (2003) and Randall & Farris (2009). Supply chain financing techniques and their impacts on firm profitability is another field of study that has had some research done, for example Gupta & Dutta (2011). Today, the emphasis in financial supply chain management has shifted from maximizing individual organizations value proposition towards more collaborative approaches,

where the whole supply network and its competitive strengths are taken into account.

3. THEORETICAL FRAMEWORK

The theoretical part of this research introduces the purchase to pay process and how it has evolved over the years. The author also examines how procurement and accounts payable departments work together to provide additional value for organizations. The impact of automation on purchase to pay process and bottom-line are presented in the end of the first part of the chapter. The second part of this chapter concentrates on collaboration in supply chains and how information technology has shaped the way how organizations go about their business. It also encompasses the meaning and benefits of various e-collaboration platforms. The last part presents the basic notions of financial supply chain management from efficient cash handling to working capital management. Some common supply chain financing services and more sophisticated financial supply chain strategies are presented in the process.

3.1 Purchase to pay process

Historically the process of acquiring goods and services has been divided between two departments: purchasing and accounts payable, where purchasing is in charge of executing and processing purchase orders, and accounts payable in charge of payments to suppliers and other parties (Palmer & Gupta 2011). The purchase to pay process varies between organizations. Typically the P2P process involves creating a purchase order, authorizing the PO, sourcing, provision of the PO to the chosen supplier, receipt of the goods, authorization of the supplier invoice and finally paying the supplier (Murphy 2012). In addition, organizations devote significant resources and time to other P2P related tasks such as contracting, ordering, inspecting, reviewing paper work, obtaining approvals and managing reports related to the procurement effort (Palmer & Gupta 2011). The above mentioned tasks are seen as time consuming and non-value added activities and this is why many companies have been automating their business processes with the help of various e-

business solutions in an effort to reduce transaction costs within the acquisition cycle (Jung et. al. 2006; Palmer & Gupta 2011). E-business solutions aim to automate the overall activities of an organization, while allowing distributed systems to communicate and share their information (Jung et. al. 2006). With the help of information technology solutions the P2P process has evolved from a series of isolated procurement and accounts payable tasks towards a single end-to-end automated process that can include multiple value adding features. These solutions are usually delivered as a more traditional on-premise solution or as a cloud-based solution that can be accessed through web-browsers / clients (Doxey 2012)

Automating the whole P2P process requires automation in the procurement department as well as in the accounts payable department (Kim & Shunk 2005; Lamon 2009). It is not surprising that many organizations have had significant challenges to form a truly integrated P2P process between these two departments (ScottMadden 2012). Many companies have been leveraging workflow management systems to automate their processes and it has been seen as a core technology of business process integration. According to Jung et. al. (2006) process automation improves organizations productivity and responsiveness, while business-to-business workflow systems electronically aid the progress of business processes between supply chain partners. It can also enhance the monitoring and administrating of their business process execution.

On the procurement side, automating the procurement process can be done by leveraging different e-procurement systems. The critical difference of e-procurement compared to traditional procurement is that it allows individual employees to order goods and services directly from their own PCs through the web (Croom & Johnston 2003). According to Kim and Shunk (2005) E-procurement systems are various internet-based business-to-business trading systems, which are located at the buyer, the supplier or the third party, with the following taxonomy:

- buyer centric e-procurement systems, e.g. intranet e-procurement systems, buy-side private e-marketplaces, and buy-side consortium e-marketplaces
- Supplier centric e-procurement systems, e.g. e-storefronts (sell-side private e-marketplaces, virtual storefronts, online shops, or merchant servers) and sell-side consortium marketplaces
- Neutral e-marketplaces, e.g. independent, third-party e-marketplaces
- End-to-end electronic document / message exchange systems (e.g. EDI, XML / EDI, extranet, email).

On the buyer side the e-procurement solution is usually connected to other existing information systems, such as ERP. This allows companies to leverage critical enterprise data present on these systems. On the supplier side, the solution is mostly connected to the suppliers order fulfillment system or product catalogs on the website of the supplier (Subramaniam & Shaw 2004). When purchasers are making acquisitions they have to create a purchase order, which is then transferred for approval through workflow. Approved purchase orders flow directly to the supplier via EDI, extranet, XML, e-mail or other formats and is then processed by the supplier (Kim & shunk 2005).

End-to-end automation of the purchase-to-pay process also requires automating the accounts payable process. Commonly, the accounts payable department has been seen as a cost center and the AP professional’s job as non-strategic (Bohn 2010). It also requires significant resources for data input, data checking, and error correction, not only during the paying process, but also in the previous document exchange phases (Korkman et. al. 2010). Automation holds the key to transform the AP department into a profit center, while also making the professionals job more relevant (Bohn 2010). Automating the AP process can be done by implementing solutions with document capture, imaging and workflow components. The solution converts paper invoices into electronic format and helps automate the process of applying data to the invoices. It also makes the archiving and retrieving invoices easier and allows users to

compare data between invoices and purchase orders. Workflow solutions can also offer advanced queuing and delegation to allocate work distribution, ensuring that specific tasks, such as approving of invoices are performed by the appropriate employee (Lamon 2009). More advanced solutions with true e-invoicing capability aim to eliminate paper altogether. These solutions work seamlessly together with e-procurement systems and provide organizations to use the same data elements and references used in the procurement process while allowing matching of invoices against purchase orders and invoices against payments (Korkman et. al. 2010).

Automation of the purchase to pay process consists from several components that need to be integrated seamlessly in order to enable efficient purchasing and invoice processing (Doxey 2012). According to Doxey (2012) components of purchase to pay solutions include:

- *Purchase order requisition:* Automated P2P process starts with electronic purchase orders. P2P solutions allow users to generate electronic purchase orders that are automatically matched to the incoming invoice.
- *E-invoicing:* Ability to receive e-invoices enables cost savings and speeds the cycle time of invoices, while eliminating paper and reducing human intervention.
- *Paper invoice capture and conversion:* Most solutions have the ability to convert paper based or PDF invoices into electronic format that can be fed into the automated approval workflow.
    - *OCR invoice scanning and capture:* Sophisticated recognition software can capture the data from paper invoices and convert them into electronic data eliminating manual processing errors.
    - *Invoice virtualization centers:* Organizations that don't want to use in-house scanning can outsource their scan & capture operations for solution vendors that will convert paper invoices into e-format.

- *Automated purchase order invoice matching:* Validated PO invoices are ready for straight-through processing. The solution automatically matches invoices to contracts, POs and receiving documents.
- *Automated non-purchase order intelligent invoice processing and workflow:* Non-PO invoices are automatically routed for appropriate approver who can immediately validate the invoice, which speeds up the process.
- *ERP Integration:* Integrating ERP and P2P solutions allows data to be transmitted electronically between systems. It ensures that important information (vendor info, PO data & financial information) are in sync between different enterprise systems.
- *Electronic payments:* Electronic payments allow easier and more consistent cash flow forecasting, while providing additional internal controls and secure payments.
- *Supplier portals:* Portals where suppliers can communicate, access information and upload invoices.

Even though automation solutions can offer significant efficiency benefits to both procurement and accounts payable department, there is no “one-size fits all” solution that would work within every organization and their various regions and departments (Bohn 2010). Figure 1 describes the evolution of P2P and how different stages of automation transform organizations P2P process. The first stage represents the buildup phase where first technologies are being implemented. In the second stage the focus is on automating tasks and the flow of transactions. In the final stage technologies are integrated seamlessly across different business functions providing an end-to-end automated solution (ScottMadden 2012).

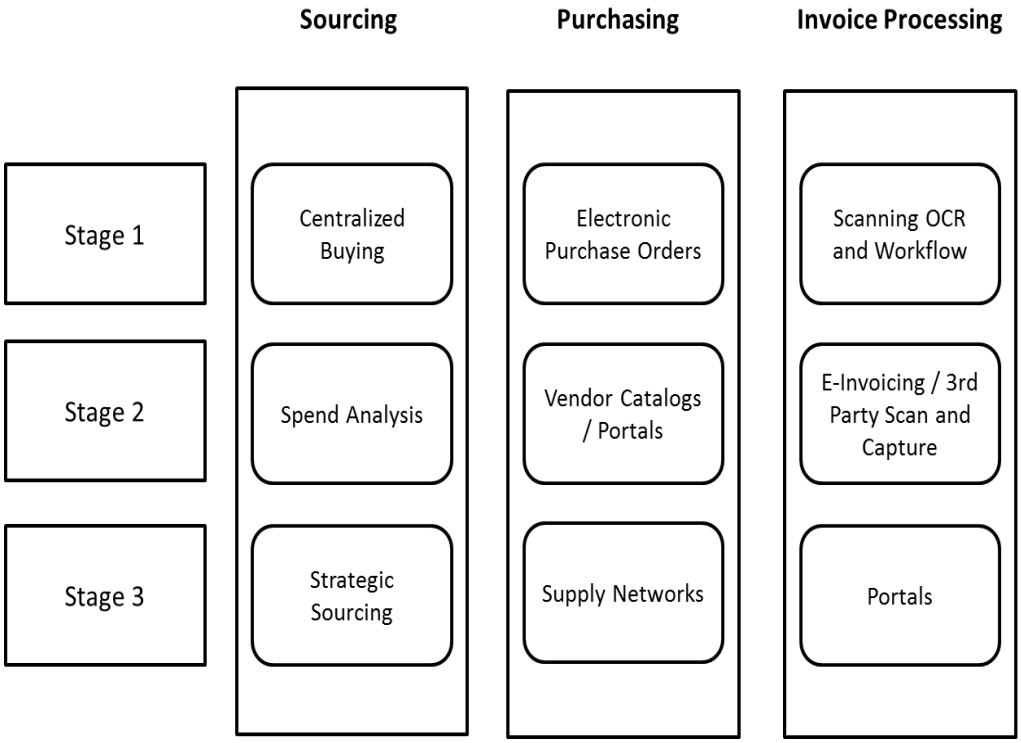

Figure 1 The evolution of purchase to pay, modified from ScottMadden 2012

Automating the whole purchase to pay process can bring about significant cost savings and operational benefits to buying organizations. The cost savings automation can deliver consist from elimination of low value added activities (Caluwaerts 2010), elimination of paper (Attaran & Attaran 2000), reduced transaction costs (Murphy 2012), shortened invoice and PO cycle time (Hawking et. al. 2004; Lamon 2009), and improved auditing and approval process (Attaran & Attaran 2000; Murphy 2012). Operational benefits include visibility into transactions (Hawking 2004; Doxey 2012), ability to analyze spend (Doxey 2012), increased corporate control and fraud prevention (Piotrowicz & Irani 2010). Automation can also enhance organizations ability to leverage several supply chain financing techniques and take advantage of early payment discounts (Camerinelli 2009; Doxey 2012). Through these enhancements organizations can realize bottom-line savings and operational efficiency that drives them towards better results. In table 1 an overview of automation benefits for procurement and accounts payable is presented.

Table 1 Benefits of automation for procurement and accounts payable departments

	Procurement	Accounts Payable
Benefits	Elimination of paper, reduced inventory, accelerated information flow, improved supplier relationships, improved auditing (Attaran & Attaran 2000) Reduced transaction costs, reduced internal processing costs, reduced purchasing price, improved budgetary control, increased transparency, spend control (Croom & Johnston 2003) Elimination of non-value added activities, improved procurement process, elimination of exceptions, corporate spend control, co-operation, faster payments, fraud prevention (Piotrowicz & Irani 2010) Improved contract compliance, shortened cycle times, improved visibility, enhanced decision making (Hawking et. al. 2004)	Visibility into transactions, shortened invoice cycle time, working capital improvements, cash flow improvements, elimination of paper, decrease in DPO, Spend analysis, ability to leverage early payment discounts (Doxey 2012) Elimination of low value-added activities, better cash management, supply chain financing, streamlined billing process (Caluwaerts 2010) Elimination of paper, Reduced storage costs, easier access to invoice information, decreased transaction cycle times, increased visibility into spending, possibility to evaluate vendors (Lamon 2009) Decreased administration, visibility and an easily tracked audit trail, reduced transaction costs, ability to leverage early payment discounts, improved supplier relationships (Murphy 2012)

3.2 Collaboration in supply chains

In the past organizations have only looked inside their own four walls to reduce waste and drive efficiency (Leng & Zailani 2012). Today, while facing uncertain environments and being more dependent on their partners to provide materials and non-core-competency services, organizations have to look outside their own operations and strive to achieve greater supply chain collaboration in order to leverage the resources and knowledge of their suppliers and customers through partnerships. This has prompted organizations to form collaborative B2B networks with their supply chain partners (Sayah & Zhang 2005; Cao & Zhang 2010). In short, supply chain collaboration means that two or more independent organizations work jointly to plan and execute supply chain operations, share important supply chain information, and collaborate on supply chain related activities efficiently and effectively (Simatupang & Sridharan 2002; Cao & Zhang, 2010). Hofmann and Kotzab (2010) argue that the goal of supply chain collaboration is to jointly create shareholder value through different collaborative activities such as planning, steering

and controlling the flow of financial resources on an inter-organizational level. Furthermore, sharing of relevant information is seen critical at each stage in the cross-border movement goods or services to ensure the transfer of title, risk, mitigation and timely payment. Collaborating organizations need to also ensure that all members are encouraged to clearly define mutual objectives and associated performance measures (Simatupang & Sridharan 2005). Even though information sharing is seen as an essential part of collaborating, many suppliers and buyers operating in B2B networks are still unwilling to cooperate or share data because of the fear that such information could weaken their negotiating position (Lee et. al. 2002).

Cao and Zhang (2010) have defined supply chain collaboration as seven interconnecting components which are: information sharing, goal congruence, decision synchronization, incentive alignment, resources sharing, collaborative communicating, and joint knowledge creation. These components add value to supply chain collaboration by reducing costs and response time, leveraging resources and improving innovation. Other potential supply chain collaboration benefits include better and more effective decision making, increased financial performance, process efficiency, cost savings through transfer of best practices, enhanced capacity and flexibility for collective actions, enhanced innovation capabilities, better inventory management, enhanced market position, and cover for demand unpredictability (Min et. al. 2002; Iyer et. al. 2009; Cao & Zhang 2010; Leng & Zailani 2012; Schloetzer 2012). It has to be noted that these benefits will only realize when all the different parties (from suppliers to customers) in the supply chain commit to cooperate (Cao & Zhang 2010).

Cao and Zhang (2010) have found that supply chain collaboration improves collaborative advantage, which enables supply chain partners to achieve synergies and also has a bottom-line influence on firm performance. Reaping all the benefits supply chain collaboration can offer

is not simple and as Walters (2008) explains ensuring cooperation and teamwork within organizations is not easy, and the problems and obstacles are even greater in a cross-organizational and global context. From a technical viewpoint, the real problems related to supply chain collaboration go beyond business processes and data transformation techniques. The greatest obstacles arise from the fact that we are dealing with interactions between two or more independent business entities and their loosely connected processes (Sayah & Zhang 2005).

In order for the supply chain to perform well and fare against competing networks, collaborating organizations should engage in trying to create win-win situations in which all participants are satisfied (Cao & Zhang 2010) By comparing the impact of business-to-business networks with and without collaboration Lee et. al. (2002) found that B2B networks should be used to establish new ways of collaboration with supply chain partners and not just for exchanging business documents. They continue that the real source of performance improvement lies in the collaboration enabled by the electronic network, and not in the electronic link itself.

EDI networks between business partners represent the first phase of B2B electronic commerce technology (Lee et. al. 2002) From EDI organizations have progressed towards e-commerce and now to e-collaboration (Chong et. al. 2009). It has been shown before that information technology is a very important part of organizations intentions to implement a collaborative supply chain. The growth of web technologies enables organizations to create competitive advantage in their supply chain through successful implementation of e-collaboration tools (Chong et. al. 2009). Johnson and Wang (2002) have defined e-collaboration as “B2B interactions facilitated by the use of web technology”. They further explain that the interactions between companies have moved from just buying and selling, to relationship building activities such as information sharing, shared decision-making and process and resource sharing.

E-collaboration tools are web-based collaborative platforms that enable users to collaborate, manage and share relevant (supply chain) information and promote easy and stable communication between business partners and / or within the organization (Costa & Tavares 2012). Sharing of important supply chain information is the key attribute that makes e-collaboration different from other existing IT tools (Chong et. al. 2009). Costa and Tavares (2012) argue that the online social network environment can bring about relevant changes in the electronic platforms behavior and transform the whole of e-business into a broader concept that is more aware of collaboration and social capital. Different variations of e-collaboration tools in supply chain management include (Marquez et. al. 2003):

- Tools to “wire” the company, offering real time information about the material flow, which is basically managed by exception
- Tools to share documents in real time
- Tools to do collaborative forecasting
- Tools to do collaborative planning
- Tools to implement automated payments

According to Costa and Tavares (2012) organizations should see social e-business platforms as an instrument to enhance business-to-business relationships and generate social and economic capital. Furthermore, Chong et. al. (2009) argue that e-collaboration tools can bring efficiency benefits from reducing the governance costs of transacting with external trading partners, relative to internal coordination costs. These tools can also be used to support relational exchange and learning (Walters 2008). Regards to purchase-to-pay e-collaboration tools can be leveraged in a variety of different tasks and also features of e-collaboration solutions can be integrated into e-procurement and AP automation solutions. Rapid interaction with suppliers and customers is also facilitated, and the internet’s high potential for personalization and interactivity allows the targeting of current clients and potential customers and suppliers when acquiring and distributing information (Walters 2008).

3.3 Financial supply chain management

The shift to supply chain collaboration has led to the fact that the management of flows, such as material, information and cash flows has increased in both complexity and criticality (Shunk et. al. 2007). Most of the research done in the area of supply chain management has been focusing on the study of materials flow and very little work has been focused on the upstream flow of money (Gupta & Dutta 2010). Financial supply chain management is a practice that concentrates on the flow of money, according to Sugirin (2009) “it refers to a specific set of solutions and services to expedite the flows of money and data between trading partners i.e. buyers and suppliers, along the supply chain”. Today, financial supply chain management has become more important as organizations may be struggling to secure short – and medium-term funding. Supply chain financing is also increasingly being seen as a method of leveraging stable business relationships between buyers and suppliers in order to achieve cheaper financing and improved payment terms. (Sugirin 2009) Although, sometimes buying organizations might see suppliers as a cheap source of cash, arm’s length relationships can be seen as ineffective in the long-run (Hofmann & Kotzab 2010).

Every time a good or a service moves in an organizations physical supply chain, there will be a corresponding flow of data and money in the financial supply chain (Sugirin 2009). As figure 2 indicates, in general the materials, component parts and finished goods flow downstream and the money flows upstream, information on the other hand can be considered to flow in both directions. The fact that information and goods flow at a different rate is important as gaps separating physical supply chain activities from their counterpart financial activities continue to cause problems for organizations (Fairchild 2005). As modern supply chains involve a network of supply chain partners, organizations need to ensure that the financial flow of money is managed effectively (Leng & Zailani 2012).

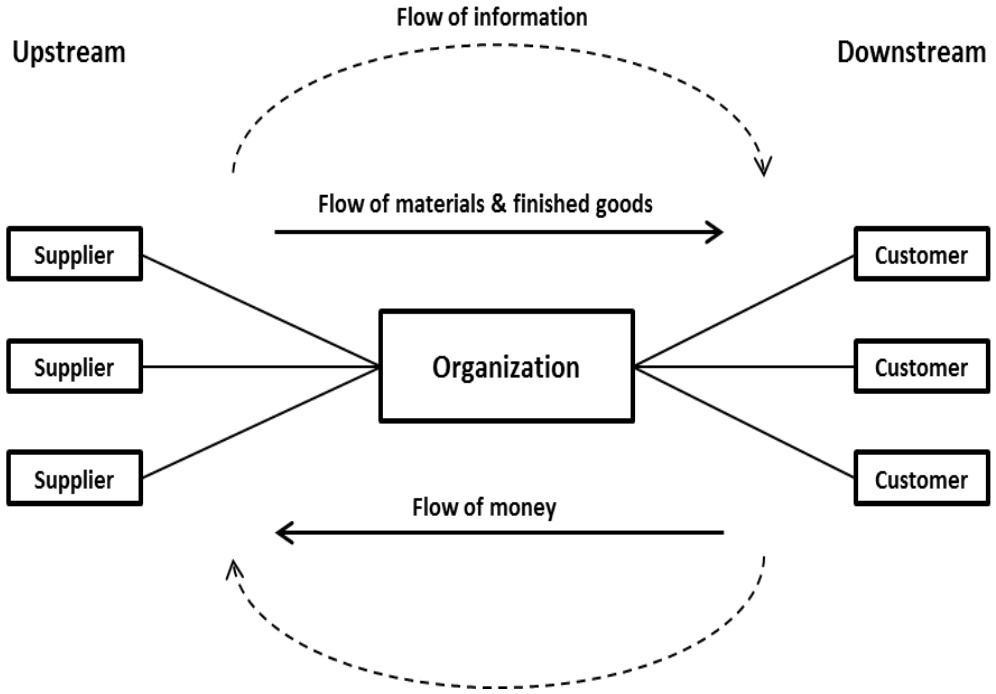

Figure 2 Financial supply chain

The management of the financial supply chain can directly impact how quickly goods and services move in the physical supply chain. In the downstream flow of goods and materials, holding of goods increases the inventory costs whereas in upstream flow of money, holding money earns interest, which is obviously more profitable (Sugirin 2009). This may create a situation where buying organizations are tempted to transfer the credit risk and capital costs to other stages in a supply chain by applying practices such as payables extensions to suppliers, enforcement of receivables collection to customers or unbalanced inventory programs (Pohlen & Goldsby 2003; Camerinelli 2008). Simply shifting costs to suppliers may result in short-term balance sheet benefits for the buyers. However, using these firm-centric techniques can backfire in the form of less financially stable, and thus a higher risk supplier base. Suppliers may be forced to delay raw material ordering, squeeze work-in-process inventories, or skimp on service levels or quality processes, when they are short for cash and have higher cost of capital. This can lead to

downstream delays and quality problems for the buyer, including manufacturing breakdowns, or late orders for key customers. In addition, suppliers are eventually forced to include the added costs in the cost of goods sold. In the long-term, shifting costs to suppliers will result in higher cost of goods versus competitors who have applied more collaborative financing practices in their supply chains. (Hofmann & Kotzab 2010) This is why recent supply chain financing research has called for more collaborative practices that can benefit the supply network as a whole (Randall & Farris II 2009; Hofmann & Kotzab 2010).

Improvements of working capital achieved through delaying payment to suppliers or enforcing the collection of money from customers can be seen as inefficient practices. Collaborative methods, based on the basic notions of supply chain management seem to be more successful (Hofmann & Kotzab 2010). According to Randall and Farris II (2010) organizations that establish strong collaborative structures may benefit by adopting a supply chain oriented approach to their financial management techniques. This approach leverages classic firm-oriented practices such as cash-to-cash cycles, cash flow, and weighted average cost of capital by smartly extending them to manage their supply chain partnerships.

3.3.1 Working capital management and supply chain financing

Most organizations require certain levels of working capital to deal with the ever changing and somewhat unpredictable financial flows (Hofmann & Kotzab 2010). Managing the flow of money is not easy. First, the inflows and outflows of cash are continuous throughout the existent of an organization. Second, future cash inflows and outflows are hard to predict, because they are linked to the movement of goods which again is dependent on the market demand. (Gupta & Dutta 2010) Other factors that may affect the financial flows include disconnected supply chain processes, inadequate credit terms, excessive stocks caused by non-bridged interfaces and sub-optimal loan decisions (Hofmann & Kotzab

2010). These problems related to working capital management cause the fact that the financial supply chain at most large organizations is filled with inefficiencies which cut through multiple subsidiaries, departments and financial institutions (Camerinelli 2009).

The working capital indicator gauges the amount of liquidity that the organization needs, on a daily basis, to execute its operations (Camerinelli 2009).

Working capital = Accounts receivable (AR) + Inventory – Accounts payable (AP)

According to Hofmann and Kotzab (2010) “working capital management aims at minimizing the capital tied up in the company’s turnover process by reducing current assets and extending current liabilities”. From an individual viewpoint this means that organizations try to have less capital tied up in non-productive stocks, shorten the collection period from customers (accounts receivable) and stretch cash payments to suppliers (accounts payable) (Farris & Hutchison 2003). Even though the above mentioned techniques might provide short-term cash flow benefits, they have been found inefficient in the long run. The arising collaborative nature of financial supply chain management is shifting the individualistic view towards more collaborative inter-firm approach, where supply chain partners compare their financial strengths in order to identify synergistic opportunities to improve their cash flow management (Randall & Farris II 2009).

Cash-to-cash (C2C) cycle represents the time-based translation of working capital (Camerinelli 2009). It is a useful measure, because “it bridges across inbound material activities with suppliers, through manufacturing operations, and the outbound sales activities with customers” (Farris II & Hutchsion 2002).

Cash-to-cash = Days sales outstanding + Days in inventory – Days payables outstanding

Days sales outstanding (DSO) is the equivalent indicator of accounts receivable and it represents the time it takes to collect and cash-in payments, whereas days in inventory (DII) simply represents the time goods stay in the hands of the organization. The last component of C2C cycle is days payables outstanding which represents the time it takes to pay suppliers. (Camerinelli 2009) The C2C cycle goal for most companies is to be close to 0 days (or even negative). Usually, the C2C metric has been used to measure efficiency and profitability with respect to the organizations financial resources. At intra-firm level zero or negative number means that the organization is profitable with respect to C2C optimization, the problem arises when this local optimization results inefficiencies in the inter-firm level and leads to supply chain sub-optimization. (Randall & Farris 2009) One has to keep in mind that long-term stability is based on the profitability of the supply chain as whole. Managing the C2C cycle collaboratively is a proactive way of working with supply chain partners and giving trade finance support to selected partners. (Sugirin 2009) When a collaborative financial supply chain approach is taken, some organizations of the supply chain might have to compromise their profit position in order to maximize the network profit position. The result is more customer value, and increased competitive advantage to the supply network. (Randall & Farris II 2009)

There are a number of different tools and strategies that organizations can leverage in order to maximize the financial value potential created by the supply network they act in (Camerinelli 2009; Randall & Farris 2009). Table 2 provides an examination of the most common SCF tools and strategies that are being used by organizations around the globe.

Table 2 Financial supply chain management tools

Strategy / Tool	Definition	Impact / Benefits
Early payment discounts	Supplier offers buyers discounts for paying before the original due date. For example an invoice is due in 30 days, but the buyer can make the payment earlier and receives a discount from the supplier. (Lamon, 2009)	Optimized working capital, savings in purchasing price and faster collection for suppliers
Factoring	Supplier sells its own credit represented by an invoice to a financial institution. This way the supplier is able to cash-in the payment in advance of the natural expiration date. The enterprise pays the financial institution for the service in the form of a discount on the invoice's nominal value (Camerinelli 2009)	Optimized working capital, improvements in financial metrics, better forecasting and trust between trading partners
Reverse factoring	In reverse factoring the financial institution promotes the initiative. Having visibility of the transaction between buyer and seller, the financial institution evaluates the financial risk associated with the buyer. Once it is clear the buyer will honor its commitment to the seller, FI will anticipate the supplier the amount to be invoiced at a discount rate. (Camerinelli 2009)	Optimized working capital, improvements in financial metrics, better forecasting and trust between trading partners
Letter of credit	A letter of credit is a document issued by financial institutions, which usually provides a payment undertaking to a beneficiary against complying documents, as stated in the LC. The buyer puts at the disposal of the seller an established amount for the provisioning of goods. Such an amount will be available to the seller only under contractual conditions. (Camerinelli 2009)	Optimized working capital, improvements in financial metrics, better forecasting and trust between trading partners
Pre shipment financing	In pre shipment financing the document used as guarantee is not the invoice or the PO. The financing is established on the buyer's level of risk. Once it is evaluated an advance of liquidity of absolute advantage to the seller is issued. (Camerinelli 2009)	Optimized working capital, improvements in financial metrics, better forecasting and trust between trading partners
Shifting inventory	This strategy relies on the idea that the value of any product is reduced further back in the SC and therefore the holding cost is less. The aim is to shift inventory from the component manufacturer to the supplier. (Randall & Farris II 2009)	Lower incurred cost, lower carrying costs, and lower inventory expenditure experienced by the network
Differing costs of capital	WACC varies between different firms within the SC. Shifting the financial burdens associated with transactions to the company with the lowest WACC is a strategy which takes advantage of that. The key idea is that the development of discount terms specific to a trading partner may guide and reward trading relationships by equally sharing and cultivating the inherent advantages of each firm of SC. (Randall & Farris II 2009)	Reduced shipping costs, Lower capital costs for the network, increased trust between trading partners, lower price for the end customer

Even though there are some variations between different supply chain financing strategies, the overachieving principle remains the same: ensure smooth flow of goods in the physical supply chain, optimize the usage of

working capital, improve financial metrics such as DPO and DSO, and leverage benefits to create competitive advantage. Collaborative financial supply chain strategies are now being applied across all industry verticals, especially within large and well-rated buying organizations. Part of buyer's strategic objective is to ensure that their suppliers remain financially stable. (Sugirin 2009) This might require that the buyer has to accept degradation in its own cash-to-cash metrics in order to bring overall gains for the company and the network through total cost reductions to the customer. By taking advantage of comparative strengths of each partner, the network can generate profits that were unreachable while operating independently. Collaborative approaches in supply chain financing increases trust and commitment within the supply chain and are likely to result in more comprehensive risk and reward sharing strategies in the future. (Randall & Farris II 2009)

3.3.2 The role of Automation in financial supply chain management

Automation of the key processes in financial supply chain management provides the foundation for organizations to take advantage of the above mentioned collaborative financing methods. End-to-end automation of the financial supply chain is a dream of the future for CPO's and CFO's. Most organizations (usually large corporations) have automated only fragments of their financial supply chain. (Camerinelli 2009) The combination of web-based technologies and support of financial institutions enables organizations to effectively leverage various supply chain financing techniques (Hofmann & Kotzab 2010). These technologies allow complete document dematerialization and automation of all administrative and operational processes, while giving financial institutions the visibility they need in order to offer their services. Automating the whole purchase-to-pay process enables total visibility into the process and provides complete and functioning body that handles the physical, information and financial flow between trading partners. (Camerinelli 2009)

For example by automating accounts payable processing organizations can effectively leverage a range of different financing options for the supplier. When buyer's invoice management solution has achieved a match of the invoice against a purchase order and a goods note, a financial service providers risk in making an advance decreases. The financier can then make an advance of the payment to the supplier, since it has a high degree of confidence the buyer will in due pay for the goods. This way the funding gap between the buyer and the supplier is bypassed and the flow of the goods in the supply chain is enhanced. (Hofmann & Kotzab 2010) Automation is also required to succeed in other SCF techniques. Even the most simple and traditional techniques such as early payment discounts can benefit from automation, since the approving of an invoice can be done faster than previously, which allows the buyer to take advantage of early payment discounts. (Doxey 2012)

Automation acts as the base for collaboration and integration that facilitates information sharing and builds trust between network partners and also provides organization with a comprehensive understanding about their current levels of accounts payable optimization (Camerenelli 2009; Sugirin 2009). While supply chain financing solutions can bring great benefits for an organization, one has to remember that different industry sectors and geographical regions require different approaches. In financial supply chain management, a one-size fits all approach is very unlikely to work. (Sugirin 2009) More mature companies that have already invested in a variety of software and technology tools in order to reduce non-value added activities and increase process automation, might have already reaped all the available benefits that come with effective flow of information between trading partners. These companies should rather focus on collaborative financial solutions by adding value through supply chain financing techniques and innovative working capital management within the supply network. (Camerinelli 2009; Sugirin 2009)

4. METHODOLOGY

This chapter explains how the research process was carried out and what kinds of methods were used to analyze the purchase to pay data. First the author provides some insight on how the research was conducted. Second, the author introduces how the data was collected, and finally the method of process mining is introduced as well as the process mining solution used in this research.

4.1 Research Process and data collection

This paragraph describes how the research was executed. The research was written between autumn 2012 and spring 2013. The research process started with identifying purchase to pay process and supply chain finance related literature. Most of the literature quoted in this research is found from academic journals and magazines. At the same time as the theoretical context was being created the author started to explore for companies to participate in the research. The research questions of this research were created based on the earlier studies and arguments made by academics and accounts payable solution vendors.

Next step was to search for suitable companies that would be willing to take part in the research. The aim was to find 3-5 large companies that had an automated accounts payable solution (invoice processing solution) and some kind of e-procurement systems at place. When potential participants were identified the collection of purchase to pay data was relatively straightforward.

The data used in this research was collected from the invoice processing systems of each participant. All the four participating companies had shared service centers in place to process a large amount of invoices annually. The data includes every invoice these SSC's have processed during year 2012. The data comprises from events (process steps) that

were conducted during the paying process and also from the attributes that were related to the invoices that were paid. All the processed invoices and their related events were stored in companies invoice processing systems from where they were retrieved leveraging SQL database. After the data was downloaded from participants' database it was then imported to QPR Software's cloud service where the data was converted into more analyzable format.

4.2 Data Analysis

Analyzing of the payment data was done leveraging process mining software. Most organizations have very limited visibility into their processes and how they work in real life. Process mining is a means that aims to correct that by extracting information from event logs maintained by organizations information technology systems to capture the business process as it is being executed. (van der Aalst et. al. 2004; Jans et. al. 2012) Examples of such systems include Enterprise resource planning (ERP), Customer relationship management (CRM), Supply chain management (SCM), Product data management (PDM), and other related systems that store process related data (van der Aalst et. al. 2010). Process mining offers a way of exploiting data gathered and stored by IT systems and provides unique insights into how processes are being carried out in organizations (Jans et. al. 2012). In practice, there is often a significant gap between what should be done and what actually happens (van der Aalst et. al. 2010). Process mining enables organizations to make comparison between how processes take place in practice versus how they are designed to work. It can be leveraged for many different purposes; examples include process discovery, conformance check, performance analysis and decision mining. (Jans et. al. 2012)

Process mining is a relatively new and highly promising way of analyzing business processes. So far the information recorded by organizations IT

systems has been rarely used to analyze the underlying processes. Process mining has been developed to improve this by providing techniques and tools for discovering these processes. (Jans et. al. 2012) Many IT systems are recording events in so called event logs. These logs provide the information one needs in order to describe the process as it is carried out (van der Aalst et. al. 2010). Van der Aalst et. al. (2010) explain that “typically, these approaches assume that it is possible to sequentially record events such that each event refers to an activity (i.e., a well-defined step in the process) and is related to a particular case (i.e., a process instance). Furthermore, some mining techniques use additional information such as the performer or originator of the event (i.e., the person/resource executing or initiating the activity), the timestamp of the event, or data elements recorded with the event (e.g., the size of an order).” Usually, the meta-data being held in IT systems encompasses at least a time stamp for transactions and an identifier for the person making those entries, although it can also go much further. The scope of the event log is constrained by IT personnel whom decide how much information the systems are recording. (van der Aalst et. al. 2010)

By using even the only basic meta-data of time and transaction ID process mining enables organizations to reproduce the history of any given transaction and to trace the relationship of that particular transaction and its conductor to all prior recorded transactions by that or related parties (Jans et. al. 2012). In this research process mining is used to evaluate the purchase to pay process and how it is conducted as opposed to how it is supposed to be.

Analyzing of the data was conducted using QPR Software’s process mining software. The software allows users to analyze their business processes leveraging existing data stored in business systems. The solution is able to visually describe complex processes and also expresses the time each process phase takes to conduct. Examples of the possible analysis one can do include:

- *Flowchart analysis*: provides an overview of the process including flow volumes, activity durations, number of cases and transition times
- *Variation analysis*: Provides visibility into all the different process variations and their relative volumes
- *Path analysis*: Shows the chain of activities that lead to a particular case event and also to the ones that follow it
- *Influence analysis*: Analyzes the impact of certain attributes that cause variations in the process (QPR Software 2013)

The analyzed data comprises from processed cases, their related events and from case attributes. The invoices that are processed by the solution are referred as cases while the process steps are referred as events. All the cases (invoices) include attributes, in other words invoice information that can have different values, are also used in the analysis. Table 3 presents all the invoice attributes and their explanations that were used in this research.

Table 3 Invoice attributes

Attribute	Explanation
Cash discount date	Indicates the date the invoices has to be paid in order to receive discounts
Company code	Code of the company that has received the invoice
Company name	Name of the company that has received the invoice
Contract number	Contract number for matching the invoice against an existing contract
Currency	Used currency
Due date days	Number of days before the invoice is due
Gross sum EUR	Gross sum in euros
Image file name	Invoice file name, mostly the name of the person creating (scanning) the invoice

Invoice status index	Indicates the status of the invoice e.g. invoice has been transferred or invoice is in the cycle etc.
Invoice type	Categories for different types of invoices for example e-invoice
Net sum EUR	Net sum of the invoice
Number of image pages	Number of pages in the invoice
Order number	Order number for matching the invoice against an order
Payment date	Date of payment
Payment term	Payment terms of the invoice
Supplier name	Name of the supplier sending the invoice
Supplier number	Supplier number

By filtering invoices with attribute values it is possible to dig deeper into the process and find reasons for particular occurrences. Attribute values can also be leveraged in various analyses that one can conduct with the process mining solution.

While all the companies had different features in their P2P solutions, the data was modified to be as uniform as possible. This means that with all the companies the process mostly starts when an invoice is received by the solution. It should be noted however that, some invoices might come to the cycle later on, if they are added manually. Event types such as “order transaction log event” that are linked to the purchasing solution used by the companies and have occurred before the invoice has been received are excluded from the analysis.

In order to be able to compare the process durations between companies the same excluding method was used in the end of the process. In most of the analyzed cases the last step of the process was when the invoice was being transferred to accounting. All the event types related to archiving, that came after “invoice transferred” were excluded from this analysis.

Archiving events were prolonging the cycle time significantly and were therefore not included in the analysis. Also, all the companies did not have archiving features in their solution so excluding those event types gives more comparable results. Event though archiving is excluded, there can be other events that come after the invoice has been transferred for example if the invoice has been modified after transfer. It has to be noted that the process can also end before “invoice transferred” these invoices can be still in the cycle or could have been cancelled. Table 4 presents the events that were excluded from each company’s process. All these event types are either from the beginning of the process or from the end.

Table 4 Excluded event types

Company	**Excluded events**
Company A	Order transaction log event, Achieved invoice has been transferred to
Company B	Archived invoice has been transferred to
Company C	Updated to ERP invoice, ERP check, Retrieval of payment information, Invoice archived by archiving service, Order interface, Archived invoice has been transferred to, Invoice updated by archiving service
Company D	Order transaction log event

5. RESULTS

This chapter introduces the results of the research. First, an overview of the analyzed data is given. In the overview the author presents some topical figures of the data. Second, different types of invoices and their cycle times are evaluated. This phase concentrates on examining the differences between handling of e-invoices versus scanned invoices. The longest lead times between process steps of both invoice types are presented as well as the impact of manual steps on cycle time. Also the impacts of matching and the amount of problem invoices that take a long time to process are examined. In the end of the chapter the inclusion of order number and contract number against invoices that do not have them are compared.

Table 5 provides an overview of the companies invoicing mass during one calendar year. The “invoices” column indicates how many invoices one company has processed during the year. It includes both e-invoices and scanned invoices. Company A had far less invoices than other companies, which can be seen also in the “events / flows” column. Events are referred here as unique process steps, and as seen in the “events / flows” column Company B has the most unique steps in their process at 93. Even though the process is mostly automated there is still a variation of different paths an invoice can go through in the cycle. Most likely, an invoice is never going to go through all of these steps until it is processed, and the amount of steps can be seen more as a representation of the complexity of the process.

The amount of transitions (e.g. flows) also provides some insight on how complicated the process actually is. For example in Company A’s case there were 622 unique transitions from one process step to another. Company B has the most transitions, even though it handles fewer invoices than for example company C. Company D had the least events and flows of all the participants and has basically the same values as

company A which processed a lot less invoices. This indicates that company D's process is the most straight forward.

Table 5 Overview of invoices

	Invoices	Events / Flows	Median Duration	Average duration	Standard deviation
Company A	24 663	56 / 622	4d 12h	9d 13h	21d 19h
Company B	230 944	93 / 1 761	5d 10h	8d 17h	18d 2h
Company C	282 538	65 / 1139	6d 4h	10d 22h	18d 1h
Company D	162 437	53 / 621	2d 13h	10d 22h	31d 5h

The last three columns cover the invoice processing cycle times. The third column "median duration" indicates the amount of time that it took to process the invoice that was in the middle of the sample. Median duration seems to be the most accurate when comparing cycle times. The median duration is considered more accurate in this research, since it is not affected so heavily by the lower and the higher ends of the samples compared to average duration. The next cell has the average duration and the last indicates the standard deviation of the samples. Companies B and C have almost the same standard deviation, whereas, company A and D have a far larger deviation in their invoice processing duration. Company D has the shortest cycle time when using the median duration but if you look at the average duration company B's invoices cycle the fastest. In company B it means that they have less "problem cases" that can take hundreds of days to process. All the companies have median durations that are under seven days. When more than a half of every company's invoices are processed this fast it enables companies to take advantage of financial supply chain management techniques and smarter cash handling.

In table 6 one can see how e-invoices and scanned invoices are distributed in each company. Company A had far more (87%) e-invoices than scanned invoices, as did company B (61%). Company C on the other hand had only 37% of all invoices coming in as an e-invoice, while Company D had only received scanned invoices. All the analyses that were conducted in this research are done using these categories.

Table 6 Invoice amounts

	E-invoices / %	**Scanned / %**	**Total / %**
Company A	21 373 / 87 %	3 290 / 13 %	24 663 / 100 %
Company B	140 070 / 61 %	90 874 / 39 %	230 944 / 100 %
Company C	105 555 / 37 %	176 983 / 63 %	282 538 / 100 %
Company D	-	162 437 / 100%	162 437 / 100%

Next, a closer look is taken to examine each company's process regarding e-invoice cycle times versus scanned invoice cycle time. While Company D only processed scanned invoices, comparison between different categories in this company cannot be done.

5.1 E-invoices vs. Scanned invoices

Only one of the companies had faster invoice processing cycle time in e-invoices compared to scanned invoices. Although it should be noted, that this research does not include the amount of time spent to handle scanned invoices before they are uploaded into the invoice processing system. This phase includes activities such as, waiting to receive the invoice, opening the envelope, validating the invoice, modifying / adding of data and scanning the invoice. As presented in figure 3 the processing cycle in this research starts when an invoice is received by the system (e-invoice) or when an invoice is created into the system (scanned invoice). The cycle

here only covers the amount of time an invoice spends in the system until it is approved and transferred to accounting for payment.

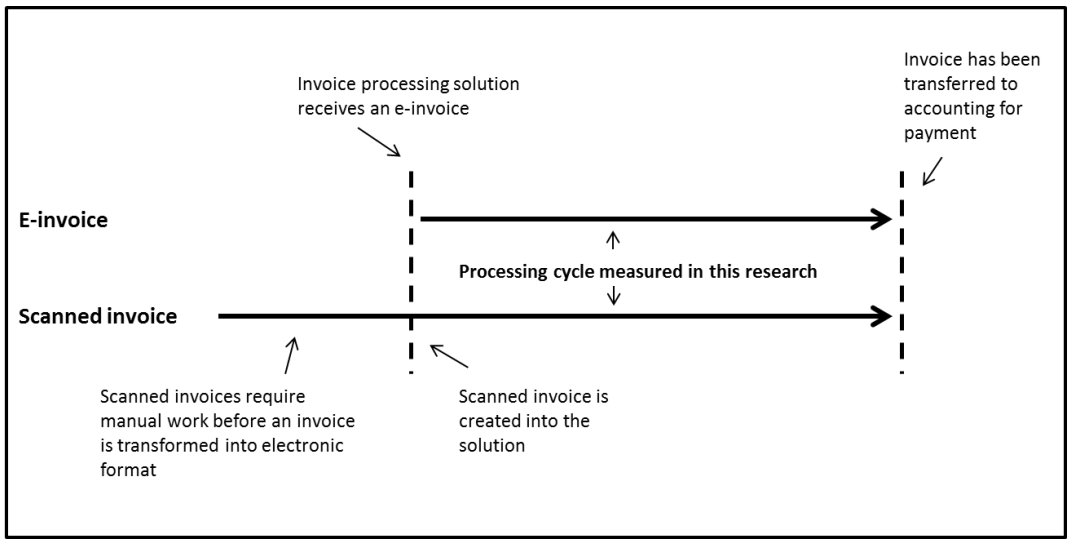

Figure 3 Processing cycle

As table 7 indicates company D's cycle time was the fastest of all companies measured in median duration. The second fastest cycle time was company A's e-invoices with 4 days 9 hours median duration. When one is looking at the average duration, Company B's scanned invoices had the shortest cycle time in 8 days 3 hours.

Table 7 E-invoices vs. scanned invoices

		Invoices	Events / Flows	Median duration	Average duration	Standard deviation
Company A	**e-invoices**	21 373	54 / 571	4d 9h	9d 16h	22d 13h
	scanned invoices	3 290	48 / 356	4d 22h	8d 14h	16d 4h
Company B	**e-invoices**	140 070	90 / 1 496	5d 21h	9d 2h	17d 16h
	scanned invoices	90 874	83 / 1360	4d 19h	8d 3h	18d 16h
Company C	**e-invoices**	105 555	63 / 883	6d 18h	12d 18h	21d 2h
	scanned invoices	176 983	57 / 844	6d 0h	9d 21h	15d 22h
Company D	**e-invoices**	-	-	-	-	-
	scanned invoices	162 437	53 / 621	2d 13h	10d 22h	31d 5h

Company A´s median duration in e-invoices is the only indication that e-invoices are actually processed quicker than scanned invoices. Companies B and C process their scanned invoices quicker measured in both median and average duration, while company D's all invoices were scanned. One reason to explain this can be seen from the "events / flows" cell, where "events" refers to unique process steps and "flows" to unique transitions between these steps. Even though the invoice processing is highly automated the number of flows shows that there are various different paths for an invoice to go through the cycle.

When the amount of flows (e.g. transitions) is compared between e-invoices and scanned invoices every company has more unique transitions from one process step to another in e-invoices. The same applies to events, which equals to unique process steps companies have in their cycle. Company B has the most transitions in their e-invoice processing at 1 496 as well as most events at 90. Company A has the least transitions in their scanned invoice process (356), but this is also due to the low amount of invoices in total. In order to find reasons for the fact that e-invoices take more time to process one has to look at the different processes with more detail and study which process steps are the most time consuming and do they require human intervention.

5.1.1 Longest transition lead times between process steps

When each company's both e-invoice and scanned invoice actual processes are examined more thoroughly and then compared against each other some interesting findings emerge. The table 8 includes every company's longest lead times between process steps in both e-invoice and scanned invoice processing measured by median duration. These steps include both pre-automated steps performed by the solution as well as manual steps performed by humans.

Table 8 Longest transition lead times

		Transition (from --> to)	Amount / % of invoices going through this step	Flow count	Median duration (days)	Average duration (days)
Company A	E-invoices	Invoice sent → Reminder sent	4 097 / 19%	5 087	2,74	2,73
		Invoice sent to regular flow → Reminder sent	2 543 / 12%	2 559	2,51	2,61
		Recurring invoice matching started → Recurring invoice matching failed	1 327 / 6%	1 327	1,00	0,76
		Reminder sent → Reminder sent	5 470 / 26%	65 040	1,00	1,09
		Invoice approved → Invoice transferred to accounting	7 749 / 36%	7 749	0,95	1,46
		Total		81 762	8,21	8,65
	Scanned invoices	Invoice reviewed → Reminder sent	257 / 8%	280	2,87	2,87
		Invoice sent → Reminder sent	929 / 28%	1259	2,82	2,80
		Invoice sent to regular flow → Reminder sent	436 / 13%	437	2,64	2,75
		Reminder sent → Reminder sent	1 225 / 37%	11605	1,00	1,07
		Invoice sent for transfer → Posting data changed	763 / 23%	764	0,81	1,21
		Total		14345	10,13	10,69
Company B	E-invoices	Invoice transferred → Informative invoice receipted	11 961 / 9%	11 962	1,31	4,29
		Invoice reviewed → Posting data changed	8 794 / 6%	9 106	0,98	2,86
		Invoice sent to regular flow → Invoice reviewed	27 293 / 19%	27 300	0,86	1,87
		Invoice sent → Posting data changed	10 375 / 7%	10 814	0,75	2,07
		Automatic processing was not finished within specific time frame. Invoice was sent to manual processing → Basic data changed	7 573 / 5%	7 574	0,74	1,47
		Total		66 756	4,65	12,57
	Scanned invoices	Invoice sent to regular flow → Invoice reviewed	23 103 / 25%	23 107	0,94	2,06
		Invoice reviewed → Posting data changed	5 408 / 6%	5 571	0,78	1,76
		Invoice sent → Posting data changed	5 830 / 6%	6 008	0,72	1,93
		Invoice reviewed → Invoice approved	37 476 / 41%	37 565	0,70	1,49
		Invoice reviewed → Invoice sent for transfer	28 499 / 31%	28 532	0,62	1,51
		Total		100 783	3,75	8,75
Company C	E-invoices	Invoice sent to ERP → reviewed in ERP	15 609 / 15%	15 609	2,35	4,62
		Comment added → Posting data changed	7 634 / 7%	7 706	2,00	5,21
		Invoice sent to regular flow → Posting data changed	44 176 / 42%	44 176	1,74	3,55
		Saved by BTIPC → Basic data check module called	11896 / 11%	11 896	1,29	1,37
		Invoice transferred to backup person → Posting data changed	11 683 / 11%	11 720	1,18	3,03
		Total		91 107	8,57	17,78
	Scanned invoices	Invoice sent to ERP → Reviewed in ERP	36 625 / 21%	36 625	2,23	5,14
		Invoice sent to regular flow → Posting data changed	85 004 / 48%	85 234	1,80	3,71
		Invoice sent → Posting data changed	23 227 / 13%	24 267	1,01	3,04
		Invoice sent → Comment added	11 220 / 6%	13 938	0,95	2,93
		Invoice sent to regular flow → Invoice sent	12 946 / 7%	12 955	0,87	2,36
		Total		173 019	6,86	17,18
Company D	Scanned invoices	Comment added → Invoice has been cancelled	8 205 / 5%	8 206	7,86	15,70
		Invoice OM matching started → The validation of an order category rule failed	17 055 / 10%	17 055	3,01	2,38
		Invoice OM matching started → Invoice sent to manual processing	9 809 / 6%	9 809	3, 01	2,38
		Invoice OM matching started → Invoice OM header matching failed	34 435 / 21%	34 435	3,00	1,98
		Comment added → Reminder sent	10 273 / 6%	12 624	2,03	2,48
		Total		82 129	18,91	25,26

In order to identify the transitions with the longest lead times that have a meaningful amount of invoices passing through, flow volume of 5,00 has been used for this analysis. This means that 95 % of the most common process variations are included in the analysis and their longest transition lead times are listed in table 8. The “transition” column indicates from which step has the invoice come from and where it is going. The amount of time spent is spent in the latter step of the column. The next column represents the amount of invoices going through the particular step in both amount and percentage. For example the longest transition lead time in Company A’s process in e-invoices has 4 097 invoices going through from “invoice sent” to “reminder sent” which is 19 % of all their e-invoices (21 373).

Flow count column on the other hand represents how many times the particular transition has occurred, in some cases it can be more than the amount of invoices due to invoices going through the same step multiple times. The last two columns indicate the duration of the particular transition in median duration and average duration. The durations are announced in days. In order to gain more information about the process steps (transitions) represented in the table, an influence analysis was conducted on each one of them to see whether some particular invoice attributes (listed in table 3) had an effect for an invoice to go through the step in question.

Company A

E-invoices

In e-invoices company A had “reminder sent” in three of their longest transition lead times, which indicates that the invoices are waiting for approval or require additional information to be added. Basically, they are waiting in the system for a human to take action so that the flow can continue. A total of 34 % percentage out of all their e-invoices is going

through this step and the median duration for invoices requiring a reminder is 12,7 days. This is a clear implication how human intervention slows down the process, when approving or data changing is not done in time and as a result reminder needs to be sent. The flow count for example in “reminder sent → reminder sent” step also implicates that reminders are required sent multiple times for certain invoices.

In figure 3 an example of an influence analysis is presented. This particular analysis is done for the transition with the second longest lead time: invoice sent to regular flow → reminder sent. The influence analysis helps to identify how big of an impact certain invoice attributes have on process variations. The first column of the analysis shows the invoice attributes (listed in table 3). Attribute value shows the value of the attribute in question. *Cases* # column shows the total number of cases in the model that have the attribute value shown and *selected* # column expresses the number of selected cases that have the attribute value. *Compared* # column shows the number of unselected cases (“cases #” - “selected #”). The next column *Selected %* indicates the percentage of selected cases. *Difference %* shows the deviation in percents between “selected %” and the average “selected %” taken from the total row. The last two columns are the ones that indicate how strong of an influence the invoice attribute has. The *contribution* # column shows the number of cases which contribute to the “difference %” i.e. the deviation from the average percentage. The last column implies the percent of the selected cases with the attribute value that contribute to the “difference %” (QPR software wiki, 2013).

The analysis clearly implicates (43 contribution-%) that when the contract number is missing an invoice is likely to go through this particular step (from *invoice sent to regular flow → reminder sent*). The second and third attribute values refer to a certain business unit, whose invoices are likely to go through this step. The fourth row attribute shows that invoices that are in Swedish currency are influencing as well. The last row refers to

invoices that have the payment term of within 30 days due net. It can be seen that the other influencers besides blank contract number do not seem to influence as strongly with 11 and 10 contribution percentages. A table of the results of all the influence analyses done to the process steps with the longest lead times of each company can be found in appendix 1.

Case attribute	Attribute value	Cases #	Selected #	Compared #	Selected %	Difference %	Contribution #	Contribution %
Contract number	(blank)	10 636	2 350	8 286	22%	10%	1 085	43%
Company name	XXXXX AB	1 552	456	1 096	29%	17%	271	11%
Company code	XXXXX	1 553	456	1 097	29%	17%	271	11%
Currency	SEK	1 366	429	937	31%	20%	266	10%
Payment term	Within 30 days due net	3 106	623	2 483	20%	8%	253	10%

Figure 4 An example of an influence analysis

The same findings emerge when the influence analysis is done to other process steps that include a reminder sent (steps 1 and 4). Blank contract number influences strongly to an invoice to go through this step. In other words when the contract number is missing or is incorrect the invoice usually goes through this transition and requires further data input or other actions, which prolongs the cycle time.

The transition with the third longest lead time, in which, a recurring invoice is failed to match to a contract. Commonly, when an invoice is processed by matching but is failed to match, the invoice requires manual data input which slows down the process. The median duration for invoices that go through this step is almost 12,4 days which is significantly longer than the median duration of all e-invoices. Blank scan and capture ID acts as the biggest influence for an invoice to pass this step. The transition with the fifth longest lead time occurs when an invoice is approved and is transferred to accounting for payment. Basically every invoice that is

approved to be paid (95 %) goes through this step, only the invoices that are cancelled or are still in the cycle are missing. Regarding this process step the influence analysis does not give clear answers on influencers due to every invoice going through this step. The sending of a reminder is automated and can be set to send reminders when an invoice is not approved in time. In company A's case most of the time is spent when the invoice is just waiting to be approved or modified.

Scanned invoices

Company A's scanned invoices have "reminder sent" in four out of their five longest transition lead times. In company A this can be seen as a bottleneck that prolongs the process in both scanned and in e-invoices. In scanned invoices up to 46 % percent of all scanned invoices require a reminder until it is approved or modified so that it can be sent back to the automatic flow. The transition where an invoice is reviewed and then a reminder has been sent is influenced by several attributes, most obviously by Russian currency (RUB) and payment term of seven days. However their influence is not that strong standing in at contribution percent of 13.

The second longest lead time between process steps is influenced by invoices that are sent to a particular business unit (20% contribution). It also shows that a certain supplier has a 13% contribution, which means that its invoices are likely to go through this path. The third transition "invoice sent to regular flow → reminder sent" only has one attribute that has over 10% contribution. The attribute is image file name, which equals to the name of the person who scanned the invoice. In the fourth transition the biggest influencer is the same business unit that was influencing the second most time consuming process step. This indicates that the particular business unit does not approve its invoices in time and often a reminder is required. The last transition has more influencers that have over 10% contribution than the other steps. These include image file name

(which usually refers to the person who scanned the invoice), payment term of 30 days and an individual business unit, all with 14% contribution.

The manual steps in scanned invoices are not as time consuming as the inability to approve invoices in time. The same thing can be seen with scanned invoices as in e-invoices, which is that reminders need to be sent far too often. While the sending of the reminder in company A might be programmed to send reminders too quickly, it still seems that approving an invoice is not done fast enough. Even though all invoices are not required to be approved and transferred to accounting within seven days or less, when they are, it provides accounting the possibility to leverage for example early payment discounts.

Company B

E-invoices

In company B the transition with the longest lead time in e-invoices is “invoice transferred → informative invoice receipted” with a median duration of 1,3 days. This step occurs after the invoice has been transferred to accounting and is influenced the strongest by invoices that are designated to a specific business unit (33%). Other influencers worth noting are due date days of 30 (20%) and payment term of 14 days – 2% / 30 days due net (16%). The next transition “invoice reviewed → posting data changed” has a median duration of 1 day. Posting data changed mostly means that the invoice has required modifying due to incorrect data. The biggest influencer for an invoice to go through this step is again a specific business unit (26%), all though it is not the same unit as in the first step. Other invoice attributes with over 10% contribution include payment term of net immediately (23%), blank order number (13%) and blank cash discount date (11%).

In the third transition between process steps an invoice has required reviewing after it has been sent to regular flow. This step has the most invoices going through at 19% out of all e-invoices. Influence analysis reveals two business units that have contributions of 27 and 25 percent. The unit with 27% contribution is the same as in the first step. The fourth transition includes posting data changed for the second time, but this time the previous step of the path is invoice sent. The influence analysis has only two attributes that have over 10% contribution. The attributes include blank order number (11%) and blank cash discount date (10%). When data modifying is required, the blank value of these attributes and their influence seems quite natural. The last transition in company B's e-invoices includes basic data changed step. Influences include two business units (16% & 11%) and blank contract number (11%).

Three separate business units showed up in the influence analysis in four out of the five transitions with the longest lead times. These units are either slow to process their invoices or are receiving invoices that require more data modifying than an average invoice. Blank order number, which might indicate that an invoice requires additional attention, was another attribute that appeared more than once in the influence analyses.

Scanned invoices

In scanned invoices the transition with the longest lead time is "invoice sent to regular flow→ invoice reviewed". A total of 25% out of all scanned invoices go through his step. The median duration is just under one day at 0,94 days. In scanned invoices none of the transitions has a median duration of over 1 day. The first transition is influenced the strongest by the same business unit (39%) that was appearing in the influence analysis in e-invoices as well. Other influencers include Image file name (22%), payment term of 14 days – 2% / 30 days due net (16%) and due date days of 30 (15%). The next transition invoice reviewed → posting data changed was also the second most time consuming step in e-invoices and has the

same business unit as the strongest influencer (31% contribution). Also a blank net sum and blank cash discount date seem to influence with 17% and 15% contribution.

The third transition “invoice sent → posting data changed” is influenced by blank cash discount date (14%) and due date days of 14 (12%). The fourth transition where an invoice has been reviewed and then approved does not have significant influencers, with the highest ranking attribute value contributing at only 4%. The fifth transition does not have strong influencers either with one specific business unit being the only attribute value reaching contribution of 10%.

In company B transitions with the longest lead times in scanned invoices did not have any general attribute values that would influence an invoice to go through these transitions. All though it can be seen that posting data changed steps (2 and 3) are being influenced by blank attribute values, which causes the need for additional data input and modifying of the invoice, which in turn slows down the process. In company B there were three business units that were influencing an invoice to go through these transitions. It seems that their invoices have more cases where an invoice needs reviewing and modifying. When the median durations are considered the transitions in e-invoices were taking more time than the transitions in scanned invoices.

Company C

E-invoices

Company C’s invoice handling process varies a little bit from the other companies. They have two invoice processing solutions (IP solution & ERP) that work side by side and invoices are often transferred between them before they are approved and sent to accounting for payment. The longest transition lead time in company C’s e-invoice processing is when

an invoice is being reviewed in the other solution (invoice sent to ERP → Reviewed in ERP). This step has over 2 day median duration and has 15% of all e-invoices passing it. The influence analysis reveals that an invoice type that is specific to the other IP solution has 81% contribution for an invoice to pass this step. Other top influencers are Swedish currency (17%) and three separate business units. The second transition "comment added → posting data changed" has a 2 day median duration. Biggest influencers are due date days of 30 (26%), business unit (23%) and invoice type of EV (21%).

The third transition where an invoice has been sent to regular flow and then posting data is being changed has 42% of e-invoices passing the step. According to the influence analysis the only attributes that have over 10% contribution are invoice type of EV (21%) and blank order number (14%). This would indicate that this type of invoices (see the second step as well) require more changes in the posting data than other type of invoices. In the fourth transition "saved by BTIPC → basic data check module called", the biggest influencer appears to be blank order number (18% contribution). In the fifth transition an invoice has been transferred to backup person for approval and then posting data has been changed. Influence analysis shows that invoices received by a particular business unit have the biggest influence for an invoice to go through this transition (31%). Other influencers include Invoice type of EV (24%), due date days of 21 (21%) and EUR currency (15%).

A common influencer in company C's longest transitions on the e-invoice side seems to be invoice type of EV. Also blank values in for example order number field seem to have an impact for an invoice to go through slower paths. Invoices received by some of the business units were also high on the influence analysis, which again could be due to their suppliers sending invoices with incorrect information.

Scanned invoices

On the scanned invoice side the transition with the longest lead time is the same as in e-invoices and also the influence analysis shows that the top influencer is the same invoice type (74%). Other influencers include particular business unit (31%), due date days of 30 (21%) and Swedish currency (19%). The second transition “invoice sent to regular flow → posting data changed” has 48% of all scanned invoices passing the step. Invoice type of EF has the strongest influence (25%) followed by blank order number (22%). The next transition “invoice sent → posting data changed” does not have any particular invoice attribute influencing this transition.

The fourth transition “invoice sent → comment added” is influenced the strongest by blank order number (18%) and invoice type EF (17%). The fifth transition has the same influencers as the previous one, but in different order: invoice type EF with 19% contribution and blank order number at 17%. Company C had two same transitions in both e-invoices and scanned invoices in the top five of the slowest transitions. The most common influencers in the scanned invoice side were invoice type EF and blank order number that were included in three out of five steps. Blank order number again refers to the fact that an invoice requires additional attention in the form of modifying.

Company D

Scanned invoices

Company D only received scanned invoices during the examination period. The transition with the longest lead time in their process was “comment added → Invoice has been cancelled”. Cancelled invoices usually stay in the cycle for a long time until they are cancelled and the median duration of almost 8 days supports this argument. The biggest

influencers for an invoice cancellation in company D were invoice status: cancelled (94%) and blank contract number (46%). The next three transitions start all from Invoice OM matching started, where the invoice is attempted to match to an order, but for some reason a match could not be found. The first of these steps ends to “the validation of an order category rule failed”. None of the invoice attributes has an over 10% influence, the strongest influencers being at 9% by a particular supplier and payment term of E30, which means that the invoice is due for payment 30 days from the start of the next month the invoice has been dated. Third transition ends to “Invoice sent to manual processing”. The strongest influencer here is blank payment term with 11% contribution.

The transition “invoice OM matching started → Invoice OM header matching failed”, has the largest percentage of invoices going through at 21%. Blank payment term value again, having the biggest influence (16%) for an invoice to go through this step. The last transition in this instance was “comment added → Reminder sent” where there were no attributes influencing with over 10% contribution. The strongest influencer here is blank contract number with 6% contribution. In company D it seems that blank values in contract number and payment term have the most impact on an invoice to go through these transitions. This is not unusual as missing or incorrect information in invoices seems to slow down the processing and prevents an invoice to be matched to order or contract.

Some of the transitions presented above are performed by the invoice processing solution and are programmed to perform an action after a certain time limit has been reached. Therefore it is meaningful to also examine the impact of the most common manual process steps on invoice cycle time. Next, the author looks at these manual process steps and their impact on median durations as well as invoice attributes that seem to influence an invoice to require passing these steps during the cycle.

5.1.2 Manual process steps

While automated P2P solutions aim towards end-to-end automation and have many automated process steps, the transitions with the longest lead times usually comprise from manual steps where human intervention is required. The most common step where human intervention is required is approving the invoice. Basically every invoice has to be approved before it can be transferred to accounting for payment.

In table 8 the most common manual process steps that tend to slow down the process are presented. The table presents the impact of these steps on median duration. These steps are often unnecessary when an invoice goes through the optimized process path and is matched to either an order or a contract. Approving of an invoice is left out of this examination, due to every invoice requiring an approval; its effect on cycle time is not meaningful. Every company's e-invoice and scanned invoice median duration is presented in the third column. The next four columns introduce the most common manual process steps and how many percentages out of all invoices in that invoice group go through the particular step. The same columns also present the median duration of invoices that require this action to be taken. For example in company A 58% out of all e-invoices require basic data to be changed, which raises the median duration for these invoices 3 days and 11 hours longer than the median duration of all e-invoices.

Table 8 Impact of manual process steps on median duration

	Invoice type	**Median duration**	**Basic data changed** % / MD	**Posting data changed** % / MD	**Comment added** % / MD	**Invoice reviewed** % / MD
Company A	E-invoices	4d 9h	58% / 7d 20h	60% / 7d 4h	38% / 9d 20h	17% / 9d 22h
	Scanned invoices	4d 22h	96% / 5d 1h	85% / 5d 20h	55% / 7d 17h	21% / 7d 22h

Company B	E-invoices	5d 21h	52% / 5d 23h	92% 6d 0h	37% / 6d 19h	92% / 6d 0h
	Scanned invoices	4d 19h	50% / 4d 20h	96%/ 4d 19h	37% / 5d 21h	94% / 4d 20h
Company C	E-invoices	6d 18h	99% / 6d 18h	90% / 7d 1h	56% / 9d 0h	74% / 7d 12h
	Scanned invoices	6d 0h	96% / 6d 0h	94% / 6d 3h	53% / 6d 23h	72% / 6d 3h
Company D	E-invoices	-	-	-	-	-
	Scanned invoices	2d 13h	59% / 5d 15h	52% / 5d 15h	24% / 12d 14h	1% / 18d 15h

In company A the step that has the strongest impact on median duration in e-invoices is invoice reviewed. It has a median duration of 9 days and 22 hours which is significantly higher than the median duration of all their invoices. Invoices requiring reviewing are influenced the strongest by blank order number (37% contribution). Comment added is another step that prolongs the e-invoice cycle time by more than five days. These invoices are also influenced the most by blank contract number (31%). Basic and posting data changed steps are again influenced by blank contract number with contribution percentages of 25 and 28. In company A's scanned invoices none of the steps has as strong as an impact on cycle time than in e-invoices. The longest median duration is again with invoices that require reviewing. Here the influence analysis reveals that payment term of 7 days due net and due date days of 7 have the biggest influence for an invoice to require to pass this step. Invoices going through the step have three days longer median duration compared to all scanned invoices. The other steps in company A's scanned invoices do not have any attributes influencing them that would have over 10% contributions.

In company B the e-invoices that require a comment to be added have the longest median duration, although it is only a little under one day longer than with all e-invoices. This step is influenced the most by blank order number, payment term of net immediately and blank cash discount date,

all with 10% contributions. Basic data changed step is influenced by invoices sent for a certain business unit (15%) and blank contract number (10%). While posting data changed and invoice reviewed had such high percentages of invoices passing them, the influence analysis does not provide clear evidence on possible influencers. Adding a comment also has the biggest impact on median duration in company B's scanned invoices where the median duration is 1 day and 2 hours longer in comment added cases, compared to the overall median duration. Biggest influencer with a 10 percent contribution here is blank cash discount date. Posting data changed and invoice reviewed do not have any attributes with strong influence due to the high percentage of invoices going through these steps. Basic data changed step is influenced the strongest by a particular business unit (20%) and blank net sum (12%). Comment added had the strongest impact on median duration in both e-invoices and scanned invoices and a total of 37% of invoices required this step in both categories.

Invoices requiring a comment are also having the longest cycle time in company C. More than half of all their e-invoices go through the step and these invoices have 2 days and 6 hours longer median duration than all e-invoices. In company C this step is influenced by invoice type of EV with 16% contribution. Due to high percentages of invoices going through basic and posting data changed, the influence analysis does not give clear answers regarding biggest influencers. In the e-invoice side the last step invoice reviewed was influenced again by invoice type of EV (22%) and particular invoices designated to a particular business unit (10%). On the scanned invoice side 53% of invoices go through comment added step and have 23 hours longer median duration compared to all scanned invoices. Biggest influencers for this step are invoice type of EF (19%) and blank order number (17%). Again, basic and posting data changed steps have such high percentages passing through that the influence analysis does not provide answers on the biggest influencers. Reviewing of an invoice has the same attributes having the strongest influence as did

comment added, with invoice type of EF (24%) and blank order number (22%).

In company D reviewing an invoice seems to prolong the process by 16 days and 2 hours, but only 1% out of all their invoices goes through the step. Biggest influencer is blank contract number with 11% contribution. Comment added is another step that slows down the process and the percentage is also a lot higher than in invoice reviewed step at 24%. The three attributes with over 10% contribution are Invoice status of no flow confirmed (22%), invoice status of cancelled (18%) and blank contract number (17%). Basic data changed is influenced by blank values in contract number and payment term, but with contribution percentages of only 6% and 5%. In posting data changed there are also no influencers over 10% with invoice status transferred having the highest contribution percent at 9%.

What is interesting to see is that all the companies have very high percentages of invoices going through posting data changed step. While companies B and C have over 90% out all their invoices going through the particular step its effects on overall median duration are not that easy to see. Most likely when an invoice is required to go through basic data changed and posting data changed step there are some errors in the invoice attributes that require modifying. In companies A and D basic – and posting data changes have a stronger impact on median duration, whereas the percentages of invoices going through the step are not as high. “Invoice reviewed” and “comment added” steps seem to have the biggest impact on median duration on each one of the companies. In order to enhance the invoice cycle times these are the steps that should be avoided in the process, since they require the most time and manual data input.

5.1.3 Invoice matching

Matching workflow is one of the key elements enabling straight through processing. Matching invoices to existing contracts and purchase orders is believed to shorten the cycle time and minimize human intervention. When an invoice is matched to a contract or an order it enables the solution to transfer the invoice to accounting in a matter of hours. Next, the impacts of matching on cycle time are examined in both e-invoices and scanned invoices. Also the author looks at the influences that impact an invoice to being processed by matching, but failed to find a match to either an order or a contract.

Company A had the most e-invoices that were successfully matched to a contract or an order. In total it had 9 313 invoices matched to a contract and 83 matched to an order. In e-invoices there were 9 015 invoices matched to a contract with a median duration of 1 day and 13 hours which is significantly lower than the median duration for all e-invoices (4d 9h). In scanned invoices the median duration is even lower standing at 6 hours 26 minutes, but there were only 298 invoices that were matched. All order matched invoices were e-invoices. These were not as quick to cycle as contract matched invoices, with a median duration 8 days and 20 hours. This is due to the fact that 73 of the order matched invoices are not matched automatically, but only after they have been failed to match first. For the 9 invoices that were matched immediately the median duration was 6 hours and 44 minutes. One of the order matched invoices had a totally different path.

There were also a meaningful amount of invoices that were processed by matching workflow but failed to find a match. In e-invoices company A had 2 008 invoices going through the step “recurring invoice matching failed”, which is 9% out of all e-invoices. Also a total of 2 083 e-invoices were failed to match to an order. The influence analysis reveals that matching a recurring invoice was influenced the most by blank scan and capture ID

(18% contribution) as well as a particular business unit (15%) and one supplier (12%). Failing to match to an order had many influencers, the strongest being blank contract number (40%), payment term of 30 days due net (29%) and blank scan and capture ID (28%). On the scanned invoices side the amounts of failed matching were not as big. Only 1% of scanned invoices went through “recurring invoice match failed”, while the biggest influencers were Australian currency (44%) and particular business unit (43%). In order matching only 3 invoices were failed to match to an order.

Company B had only 191 invoices matched to contract and none that were matched to an order. In e-invoices the median duration for contract matched invoices was 2 days and 17 hours which is again much lower than the median duration of all invoices in company B. In scanned invoices the median duration was 82 days 2 hours, but there were only 35 invoices in this category. Although there were so few invoices that were matched in company B, the amounts of invoices failed to match implies that invoices are actually attempted to match. In e-invoices 28% passed the step “invoice CM matching failed”, biggest influencers here were payment term of net immediately (25%), blank order number (15%), business unit (11%), and blank cash discount date (10%). In order matching 13% of e-invoices went through “invoice OM header matching failed”, influenced by business unit (67%), due date days of 30 (29%), blank contract number (29%), and two different payment terms. In scanned invoices the percentages of invoices passing these steps were lower. Total of 6% were failed to match to a contract and 10% to an order. Influencers in failed contract matching were image file name: scanner 1 (20%), payment term 30 days due net, 8 days -2% (17%), payment term net immediately (14%), due date days of 7 (13%) and blank order number (12%). Failing to match to an order was influenced by the same image file as above (18%), other influencers had fewer than 10% contribution, but one interesting was blank invoice type (8%).

Company C did not have a meaningful amount of invoices being successfully matched with only two invoices matched to a contract. As well as company B also company C had invoices being processed by matching, but basically all of them failed to find a match. In e-invoices 10% were failed to match to a contract and 42% were failed to match to an order. Failing to match to a contract was influenced the strongest by blank order number (16%) and due date days of 14 (11%). Failed order matching was influenced by business unit (22%) and due date days of 21 (21%). On the scanned invoices side the percentages were much lower with 2% failed to match to a contract and 0% (826 invoices) to an order. Failed contract matching being influenced by EUR currency (39%) due date days of 14 (30%), image file name (21%), blank order number (19%), invoice type EF (18%) and blank payment term (10%). Biggest influencers in failing to match to an order were image file name (17%), specific payment date (11%), due date days of 30 (11%) and number of image pages: 1 (10%).

In company D 61 271 invoices were successfully matched to an order. In total this is 38% out of all invoices processed by company D. The median duration of matched invoices was only 13 hours and 49 minutes, which was only bettered by company A's scanned invoices but with a much lower invoice mass. While the matching rate in company D was fairly good there were still 64 228 (40%) invoices that failed to match. The influence analysis in this instance does not provide any invoice attributes that would have over 10% contribution for an invoice to fail to match. Even though there are a lot of invoices that are failed to match, company D's matched invoices provide a good example how matching enabled straight through processing shortens the cycle time significantly compared to companies B and C.

The low median durations of matched invoices are due to more straight forward process (less transitions & events) and less manual tasks conducted by humans. Companies B and C had very few invoices that

were matched to either an order or a contract. On the other hand in companies A and D where the number of matched invoices were higher the median durations were lower. This is a clear implication of how matched invoices are processed faster than invoices going through the regular flow.

5.1.4 Invoices that take over 30 days

In order to find out whether e-invoices are processed faster than scanned invoices, it is worthwhile to find out which ones have more invoices in higher end of the sample. The longer average duration and standard deviation (presented in table 6) could implicate that e-invoices have more “problem” cases that take time process and require more human intervention. The definition of “problem case” in this research is an invoice that takes over 30 days (one month) to process. This has been derived by looking at the most common due date day values of each company. While companies A, B and C are Finnish and company D from UK the due date days vary a little bit between these countries. The most common due date days among Finnish companies were 30 days, followed by 14, 21, 17 and 7 in that order. In company D the most common payment terms were E60, E30 and I30 , where the letter ‘E’ means that an invoice dated today is due for payment from the start of next month +30 days, while the letter ‘I’ stands for, due for payment 30 days from the invoice being dated. If an invoice is in the cycle over 30 days it cannot be transferred to accounting for payment which might result in additional late payment fees, particularly in the Finnish companies where all the top five most common payment terms are 30 days or under.

In company A 4,8% (1 036 invoices) out of all e-invoices took more than 30 days to process. In scanned invoices the percentage was a little lower at 4,6%. Influence analysis conducted for these invoice categories indicates that on the e-invoice side the biggest influencers for an invoice to be included in this group are blank contract number (25% contribution),

due date days of 30 (20%), payment term within 30 days due net (14%) and blank payment date (14%). In scanned invoices biggest influencers include USD currency (23%), particular supplier (22%), business unit (21%) and number of 2 image pages (15%). Company B has 3,1% (4 360) of e-invoices and 3,4% (3 085) of scanned invoices taking over 30 days to process. In e-invoices biggest influencers are payment term of net immediately (12%), blank order number (12%) and blank cash discount date (8%). Scanned invoices in company B are influenced the strongest by payment term immediately (26%), Invoice status value 4 (16%) and blank cash discount date (14%).

Company C has the highest percentage of e-invoices cycling over 30 days at 6,9% (7 294). In scanned invoices the percentage is lower standing in at 4,1% (7 250). Biggest influencers in e-invoices are invoices received by a certain business unit (21%), due date days of 21 (17%) and invoice type EV (14%). In scanned invoices strongest influencers are business unit (11%) and blank payment date (10%). Company D has 8,1% of their invoices taking over 30 days to process. Even though company D had the lowest median duration of all companies at the same time it has the most problem cases at 13 201 invoices. Biggest influencers in company D include cancelled invoice status (32%) and blank contract number (22%).

While the percentages of invoices that take more than 30 days are relatively low, the amount of resources used to process these invoices could be much more than with invoices processed faster. Conventionally these problem invoices require manual data modifying and other related work such as contacting suppliers to solve disputes, which would not be required had the invoice been matched to a contract or an order. The differences between companies A, B and C’s e-invoices and scanned invoices do not seem to be that big in this area. Only company C had notably higher percentage in e-invoices that take more than 30 days to process compared to scanned invoices. The evidence from the influence analysis shows that blank spaces in invoice attributes in both e-invoices

and scanned invoices seem to impact an invoice to be included in these “problem” groups. All though some invoices may have payment terms that are over 30 days and might not require to be approved before that, it could still be better to have them in accounting ready for payment in order to leverage possible early payment discounts and allow finance department to execute efficient cash handling.

5.2 Invoices with order or contract number

This chapter examines how the processes of handling invoices that have an order number or a contract number differ from those that do not have them. Invoices from goods and services ordered through e-procurement systems commonly include either an order number or a contract number. When the invoice processing solution identifies the order number of an invoice it can then be matched to order, which leads to straight through processing and ideally the invoice can be transferred to accounting in a matter of hours. The same goes with invoices including a contract number. The table 9 presents the distributions between invoices with order number and no order number as well as invoices with contract number and no contract number. It should be noted that some invoices can have both order and contract number.

Table 9 Order and contract numbers

		Invoices	%	Median duration	Average duration
Company A	Order number	2 032	8 %	6d 4h	9d 19h
	No order number	22 631	92 %	4d 2h	9d 12h
	Contract number	11 086	45 %	1d 17h	6d 8h
	No contract number	13 577	55 %	7d 5h	12d 3h
Company B	Order number	31 069	13 %	5d 5h	6d 19h
	No order number	199 877	87 %	5d 12h	9d 1h
	Contract number	52 522	23 %	6d 2h	10d 19h
	No contract number	178 424	77 %	5d 3h	8d 3h
Company C	Order number	100 386	35 %	7d 1h	13d 18h
	No order number	183 413	65 %	5d 22h	9d 9h
	Contract number	10 187	4 %	5d 18h	9d 0h
	No contract number	273 612	96 %	6d 4h	11d 0h

Company D	**Order number**	162 433	100 %	2d 13h	10d 22h
	No order number	4	0 %	2d 12h	2d 12h
	Contract number	148 838	92 %	2d 13h	8d 21h
	No contract number	13 599	8 %	6d 19h	33d 4h

In company A the amount of invoices that have an order number is relatively small, only 8% out of all invoices. It seems that invoices that do not have an order number are processed faster than those that have it. One reason for this might be that company A only had 83 invoices that were matched to an order, which would indicate that order matching is not working efficiently. It is the opposite with invoices including a contract number. Median duration of only 1 day and 17 hours is significantly lower than that of invoices that do not have a contract number. Again the explanation lies in matching, which is done well in company A with invoices including a contract number. A total of 84% (9 313 / 11 086) out of all invoices with contract number are matched to contract.

Company B had only 31 069 invoices including an order number and almost 200 000 invoices that were missing it. Measured in both median and average duration those with order number were processed a little bit faster than invoices that did not have it. Even though there were no invoices matched to an order. The percentage of invoices including a contract number was a little higher at 23%. While the median duration indicates that invoices without a contract number were processed faster. Only 191 out of all invoices including a contract number were matched to a contract. All though, these matched invoices only took 3 days and 8 hours to process, which is much lower than the median of all invoices with contract number. This indicates that those with contract number and no match are requiring more time to process.

In company C order number invoices were slower to process than those with no order number. Also there were no invoices matched to an order. On the other hand invoices including a contract number were processed faster than those missing it. Matching was practically nonexistent on these

invoices as well, with only two invoices matched to a contract. Still the processing of invoices with contract number was faster than the overall median duration of company C's invoices.

Company D had by far the most invoices with an order number. There were only 4 invoices that had order number missing in the whole sample. The shortest median duration out of all companies is mostly due to the fact that company D's invoices were missing the least key data. Also their matching rate in invoices with order number was the highest at 38%. Company D also had the most invoices including a contract number. Invoices with contract number were processed over 4 days faster measured in median duration than invoices missing a contract number, even though no invoices were matched to a contract.

Company B was the only company that processed their invoices that did not include a contract number faster than those with contract number. Invoices with order number were processed faster than invoices missing it in companies B and D. Order number and contract number are very important invoice attribute values for efficient invoice processing and are the key enablers of matching. Companies A and D that have the most invoices matched to a contract (company A) and order (company D), have also the highest percentages of these invoice values. It is not a coincidence that these companies have the shortest invoice processing cycle times.

6. DISCUSSION

This chapter summarizes the results of the research, while also providing reasons for particular occurrences. First, the processing of different types of invoices is looked into. Second, different process steps and the transitions between them are examined and how removing some manual steps would impact the process and its cycle times. In the middle of the chapter the author discusses how the inclusion of order or contract number affects the cycle times of the process. In the last part suggestions on how to develop the process are made for each company.

6.1 Processing of different types of invoices

Four companies with automated invoice processing solutions participated in this research. Three out of these four had processed both e-invoices and scanned invoices, while one only processed scanned invoices. Median duration was used as the main measure when invoice cycle times were compared between and within these organizations. The only company to process their e-invoices faster than scanned invoices was company A (table 6). The main reason for company A's fast processing of e-invoices is due to efficient contract matching in e-invoices. Companies B and C processed their scanned invoices quicker, while company D only had scanned invoices coming into their solution. The lack of matching in companies B and C does not really explain why their e-invoices are cycling slower than scanned invoices. While matching can boost the cycle times it can also be done effectively with scanned invoices as the evidence from company D proves. Company D had the lowest median duration out of all companies, but at the same time their high average duration and standard deviation reveal that they had more invoices in the higher end of the sample than other companies.

One of the reasons why scanned invoices seem to be faster to process in companies B and C is that the processing of e-invoices seems to be more

complex. The amount of unique process steps and also the amount of unique transitions between these steps are higher in e-invoices in each of the companies that processed both e-invoices and scanned invoices. Invalid invoice information could be one reason to explain why e-invoice handling process seems to be more complex than that of scanned invoices. Although it should be noted that even though company A has the lowest values out of all companies in process steps and transitions in their scanned invoices, they still process their e-invoices faster. This proves that the low amount of process steps and transitions does not always realize in faster processing durations. Company D's process can be considered the best in terms of cycle time and it is also fairly simple even though they process over 160 000 invoices a year. When company D's amount of process steps and transitions is compared to companies B and C who also processed a huge number of invoices during one year, it seems there are less variations in company D's process. The simplicity of the process and minimizing of exceptions during the process are results of better process automation.

E-invoices also seem to have more problem cases that take over 30 days to process. In two of the three companies that processed both e-invoices and scanned invoices there were more problem invoices on the e-invoice side percentage wise. The biggest difference between these groups was in company C where 6,9% of e-invoices and 4,1% of scanned invoices took more than 30 days to process. Also company A had relatively more problem cases in e-invoices than in scanned invoices, but the gap between them was not as big, at only 0,2%. On the other hand company B had more problems in scanned invoices, all though the difference was only 0,3% between scanned and e-invoices. The most common invoice attributes that showed up in the influence analysis with these invoices were blank values in for example order & contract number, cash discount date and payment date. Other influencing attributes included various payment terms, individual business units and invoice status values. These

invoice attributes were clearly influencing an invoice to be included in the group that took more time to process.

6.2 Process phases

The longest transition lead times of each company on both e-invoice and scanned invoice side were also examined. The process transitions listed in table 7 ignore the rarest 5% of the steps. This is done to eliminate single transitions that take long time to complete. These transitions might only include one invoice and are therefore excluded from this analysis. When the total median durations of these transitions are examined, one can see that only in company A where e-invoices were processed faster (measured in median duration) the total median duration of the top five longest transition lead times is lower in e-invoices than in scanned invoices. Companies B and C on the other hand processed their scanned invoices faster and also had lower total median durations in these transitions. Company D's longest lead times in scanned invoices have the longest total median duration of all companies. The total median durations of the transition lead times are in line with the fact that company A processed their e-invoices faster than scanned invoices and also had lower total median duration in these steps compared to scanned invoices. On the other hand companies B and C where scanned invoices were processed faster, the total median duration of transitions between process steps was higher in e-invoices.

Some of the examined transitions include pre-programmed steps, such as sending a reminder, that are conducted once a certain time limit is reached. Therefore looking at the manual steps (presented in table 8) in both e-invoices and scanned invoices provides more insight why e-invoices are processed slower in companies B and C. In company A, where e-invoices cycle faster, 58 % out of e-invoices and 96 % in scanned invoices require changes in basic data. These are invoices that have not found a match and require human intervention. In company A changes

required in posting data are much fewer in e-invoices than in scanned invoices. The reason for this is efficient matching that reduces the need of human intervention and manual data entry or modifying. In company D where matching is also done effectively the percentages requiring posting or basic data to be changed are much lower than in company C, that basically did not have any matching in their process. Company B's percentages in basic data changed are not that high, but almost every invoice goes through posting data changed step, whereas the same percentages in company A's e-invoices and company D's scanned invoices, where matching rates are high, were only 60% and 52% respectively.

Invoices that required a comment to be added or required reviewing were taking the most time in each one of the participating companies. Reducing the amount of invoices requiring these steps is one key to shorten the invoice processing cycle times. For example in company A excluding all the e-invoices that required commenting from the examination would reduce the median duration from 4 days and 9 hours to 2 days and 3 hours. This would mean a reduction of over 2 days in median duration. While 38% of all e-invoices in company A required a comment, getting this down to 0% would probably be impossible, but still if the percentage would be managed to drop at least a little bit the impact on cycle time could be significant. If the same excluding is done to e-invoices requiring reviewing company A's e-invoice cycle time drops to 3 days and 10 hours, which is also almost a day faster than when these invoices are included. On the scanned invoices side the impacts are even stronger, for instance excluding comment added invoices brings the median duration for scanned invoices down to 1 day and excluding reviewed invoices, down to 3 days and 15 hours from the original 4 days 22 hours. It should be noted that invoices going through the above mentioned steps basically always also go through either posting data changed or basic data changed step or in some cases through both steps.

In company B's e-invoices the biggest prolonging impact on cycle time comes from adding a comment. A total of 37% of all e-invoices require a comment to be added and for these invoices the median duration is 6 days and 19 hours. When comment added invoices are removed from the examination the median duration drops to 5 days and 13 hours, which is 8 hours less than the overall median duration for e-invoices. The impact is not as big as in company A, but it still does shorten the cycle time. Other manual steps do not have that big of an impact on median duration, so excluding them is not meaningful. As well as in e-invoices, adding a comment also prolongs the cycle the most in scanned invoices. On scanned invoices side, removing comment added invoices shortens the cycle time by 19 hours. This again indicates that aiming to reduce the amount of invoices that require comments would shorten the cycle time and also free employees to focus on more valuable tasks.

Again, in company C the comment added invoices seem to impact median duration the most. If comment added e-invoices are removed the median duration for all e-invoices drops to 4 days and 20 hours, which is almost two days less than the median when comment added invoices are included. The same effects can be seen on the scanned invoices side where the median duration drops to 4 days and 23 hours, which is little over a day less than the overall median duration in scanned invoices. Other manual steps have too big percentages of invoices passing them to exclude these steps form the examination. Also, their impact on median duration is not as big.

In company D where the percentage of invoices going to straight through processing is the highest, adding a comment and reviewing an invoice prolong the cycle time significantly. Excluding invoices that required reviewing does not impact the median duration at all, due to such low amount (1%) of invoices passing the step. It is the opposite with invoices that require a comment. Excluding these invoices drops the median

duration to 14 hours and 58 minutes, which is exceptionally good cycle time.

It seems that removing invoices that require commenting from the examination would shorten the cycle times in each one of the companies. The impacts were the strongest in companies A and D, but also companies B and C would benefit from minimizing the amount of invoices that require commenting. The influence analyses show that invoices that are missing contract or order number are most likely to require commenting. When these invoice values are missing an invoice requires more attention and is not able to match to an order or a contract. In order to increase the amount of invoices that would have these values companies need to work in collaboration with their suppliers to ensure that these attribute values are filled accordingly.

6.3 Processing invoices from maverick purchases

While order number and contract number are essential for an invoice to be processed effectively, many invoices are still lacking these values. As seen previously, blank values in either order or contract number seem to influence an invoice to require more attention and manual human intervention. The evidence shows that invoices that have some sort of contract number are processed much faster than invoices that do not have it. The exception is company B where it is the other way around and invoices without contract number were actually processed quicker.

Missing order number did not have such big impact and in fact in companies A and C invoices without order number were processed faster. In company D this comparison is not relevant while basically all their invoices had order number. Although company D’s efficient order matching and short median duration can be seen to derive from the high percentage of invoices having this value, which would implicate that it is important to have. According to these results contract number is a key

invoice attribute value that should be included in the invoice in order to ensure quick processing times. Companies A and D, which had the highest percentages of invoices including a contract number also had the lowest overall median durations and were able to benefit from invoice matching. Matching requires these fields to be filled in order to match the invoice to existing contracts. This is another indication of the importance of this invoice attribute value.

Usually the absence of order and contract number depends on whether the purchase has been done following appropriate purchasing procedures. Maverick purchases commonly do not include at least a contract number and could therefore take longer to process. Another reason for absence of these values is the supplier, who sends the invoice. If the invoice values are not filled accordingly, invoice matching cannot function and manual human intervention is required in order to transfer the invoice to accounting for payment. Ensuring that the critical invoice attributes are included companies should engage in closer collaboration with key suppliers in order to take advantage of invoice matching capabilities. When suppliers provide invoices that do not require modification and are therefore processed faster, it is also more likely that the supplier will get paid in time.

6.4 Process enhancements

Companies A and D had the most effective invoice handling process in terms of cycle times. These companies were also the ones that had the highest invoice matching rates. Company A had the most invoices matched to a contract and company D most to an order. In companies B and C matching was basically non-existent and therefore their cycle times were not as good. Even though each of the companies reached median durations of less than one week in their invoice processing, there is also potential for streamlining.

The most obvious enhancements are related to raising the matching rates of each company, especially in companies B and C. Higher matching rates would minimize the work required to modify invoices in “posting data changed” and “basic data changed” steps and also would decrease the amount of invoices that require commenting or reviewing. One way to achieve this could be closer collaboration with suppliers in order to receive invoices with more accurate data. Also if more purchases are centralized to preferred suppliers and ordered through e-procurement systems, matching to orders or contracts would be easier, as seen in company D.

All the companies could benefit from an invoice validation service, which would verify the invoice data and that all required information is included in the invoice. By validating the chosen invoice fields such as order number or contract number before the invoice is taken into the processing flow, companies could increase the amount of invoices going to straight through processing (e.g. matching). Even if the invoices would not match, more accurate information in invoices would still decrease the amount of human intervention. Validation service could also provide a collaborative platform where suppliers could modify the invoice if required fields are missing or incorrect. Only after all required fields are included the solution would take the invoice into the processing flow. The service should not be used for all invoices, but it could be leveraged with suppliers that are used regularly and send multiple invoices every year. The quicker cycle times enabled by matching would also provide the opportunity for companies to leverage third party supply chain financing services as well as more sophisticated and collaborative financial supply chain strategies.

Another valuable service which all the companies could benefit from is a mobile solution for invoice approving and modifying. While approving of invoices might sometimes prove to be a bottleneck in the process, like for example in company A, the ability to access invoices anytime and anywhere could prevent this. The other companies could also benefit from mobile solutions that would allow employees to approve invoices on the go

or modify them if required. This would increase flexibility in the process as well as quicken the cycle times. Mobile solutions could also be leveraged at the beginning of the process to create purchase orders and handle other purchasing related tasks. As Ruhi and Turel (2005) put it, mobile technologies and applications offer an advanced level of driving efficiency, while boosting the flow of information within and amongst supply chain partners.

As demonstrated in the previous chapter (5.2) reducing the amount of invoices that require commenting would quicken the processing in each one of the companies significantly. Invoices that require commenting also mostly require changes in the data, which means that human intervention is mandatory. For companies B and C the obvious next step to enhance the process would be engaging in efforts to raise the amount of matched invoices. The impacts of invoice matching on process cycle times are undisputed. When an invoice is automatically matched to a purchase order or an existing contract it leads to straight through processing where the only manual task is approving the invoice. Invoices that are matched, minimize the use of resources in the AP department and speed up the process.

Companies B and C could try to emulate the process of either company A or D, where company A concentrated on matching invoices against existing contracts and company D against purchase orders. These efforts should be started together with suppliers. If companies are to decide engaging in contract matching they should first identify the suppliers whose invoices they wish to match. The best fits are suppliers who send invoices frequently (possibly on a monthly basis) or suppliers who send large consolidated invoices. After the targeted suppliers are identified, the contracts can be added into the system one by one. If companies wish to engage in boosting the number of order matched invoices, the amount of maverick purchases need to be cut. This would mean that goods and services should be ordered through appropriate channels and from

selected suppliers. When purchases are made following pre-set company guidelines it is easier to match invoices against purchase orders.

In company A matching to contracts was working really well, but on the other hand there is much potential to improve their order matching. During the examination period company A only matched 83 invoices to a purchase order with median duration of 8 days and 20 hours. Compared to company D's cycle times their order matching is not efficient. Raising the amount of order matching invoices as well as reducing their cycle time is an area where company A should focus. While company A operates in an industry where almost all their purchases are indirect and due to the low amount of invoices per year company A would probably not benefit from supply chain financing services as much as the other companies with their invoicing volume. At this stage company D's process looks best suited for leveraging third party SCF services such as factoring or reverse factoring. Company D should also focus on minimizing the amount of invoices that require commenting, because these invoices are the ones slowing down the process the most. Even though their order matching rates are high, it can still be raised, while there were over 60 000 invoices processed by matching that failed to match to a purchase order. Still, company D's process was the fastest of these companies which creates a good foundation for them to engage in SFC services as well as collaborative financial supply chain strategies that can impact their supply chain's productivity and efficiency as a whole.

Even though there is much potential for streamlining in each company's process, all companies still reached median durations of less than one week with both invoice types. While the median durations fall below 7 days, it enables companies to practice proactive and collaborative cash flow management, while also allowing companies to take advantage of early payment discounts offered by suppliers. The next level where companies can search for efficiencies lies in collaborative financial supply chain strategies such as inventory shifting and differing costs of capital.

These more sophisticated strategies cover the whole supply chain and aim to provide value for the supply chain as a whole starting from the component manufacturer and ending to the customer.

7. CONCLUSIONS

The main objective of this research was to examine organizations purchase to pay process and how their invoices are processed in an automated invoice processing solution. In this chapter the main findings of the research are concluded. The author will provide answers to the research question and its sub questions. Particularly the author was attempting to find out whether e-invoices are processed faster than scanned invoices and what are the parts of the process that require the most time and resources. Other objectives included looking into invoices that had order or contract number and examining if there were differences in processing invoices with these attribute values and those that did not have them. Finally, this chapter will provide suggestions how to make the process more effective and gain more value out of it.

Four companies from different industries participated in the research by providing their invoice data from one calendar year. The data was exported from companies invoice processing systems and then uploaded to a process mining solution for analysis. Some limitations were set for the data to be as uniform as possible by excluding irrelevant process steps from both the beginning and at the end of the process. This enabled the author to conduct comparisons between different organizations and their invoice processing cycle times. Three of the four participating companies were receiving both e-invoices and scanned invoices, while one of them only received scanned invoices. Next, the research is concluded by providing answers to the research question and its sub questions. The research question was as follows:

- ***Are e-invoices faster to process than scanned invoices?***

The evidence from companies A, B and C that processed both e-invoices and scanned invoices does not fully support the argument that e-invoices are faster to process than scanned invoices. Although it should be

remembered that this research only measures the time an invoice spends within the invoice processing solution. The manual tasks conducted by humans that are related to the processing of scanned invoices such as opening an envelope, validating the invoice and scanning it are not included in this examination. Companies B and C had processed their scanned invoices faster than e-invoices. Company B had processed more e-invoices than scanned invoices. Scanned were processed 1 day and 2 hours faster compared to e-invoices (measured in median duration). In company C there were more scanned invoices than e-invoices, while the difference between these groups' cycle times was 18 hours. The reason why these companies process their scanned invoices quicker seems to lie in the complexity of the processing of e-invoices and the time used in the most time consuming process steps. Company C also had relatively more problem invoices that took over 30 days to process in their e-invoices compared to scanned invoices.

In company A, e-invoices were processed faster and they also received far more e-invoices than scanned invoices. Although, the difference between scanned invoices and e-invoices was only 13 hours. The more efficient processing of e-invoices in company A is due to successful matching of invoices to existing contracts. The median duration for matched e-invoices was only 1 day and 13 hours and it was even faster with scanned invoices at 6 hours and 44 minutes, but with a much lower invoice volume. Even though company A's e-invoice handling process was more complex than that of scanned invoices and they also had more problem cases in e-invoices, thanks to high matching rate their median duration in e-invoices was still lower.

All in all e-invoice processing seems to be more complex and has more process variations. The more complex the process, the more human intervention it requires, which in turn slows down the process. The complexity of the process and wide range of different variations seems to stem from invalid invoice data that requires modifying and causes an

invoice to depart from the optimized path. Next, the first sub question is examined. The author looks into the longest transition lead times and how the manual steps impact invoice processing cycle times.

- ***Which transitions from one process step to another have the longest lead times and what kind of an impact do the manual process steps have on cycle times?***

Five of the longest transition lead times of each company's e-invoice and scanned invoice processing are presented in the table 8. These transitions included many manual steps as well as some pre-automated steps that are performed by the solution automatically. The transitions that have high percentage of invoices going through are the ones companies should concentrate on in order to boost the invoice cycle times. The typical invoice attributes that were influencing invoices to go through these transitions included blank values in order number, contract number, cash discount date and payment term. Other influencers worth mentioning were particular business units, various payment terms and image file name, which equals to the person creating / scanning the invoice. Full list of the influencing attributes can be found in appendix 1. Looking at the common influencing attributes one can come to a conclusion that invalid or missing information seems to push invoices towards these transitions, which prolongs their processing and creates a need for human intervention.

The impact of manual human conducted tasks is another factor that prolongs the cycle times. Invoices that require commenting are the ones that impact the cycle times the most in each one of the companies. The impact of other manual steps is not as big, although they can be seen to slow down the process as well. Invoices that go through comment added step mostly also require changes in posting or basic data. When invoices that required commenting were excluded from the examination every company's cycle time dropped significantly. When companies are looking to enhance the process these are the invoices they need to reduce. The

results from influence analysis suggest that increasing the number of invoices that have either order or contract number should minimize the amount of invoices that need commenting. The next sub question addresses the issues related to the processing of invoices from maverick purchases.

- ***Are invoices with order or / and contract number faster to process than invoices from maverick purchases?***

Invoices that are missing an order or a contract number are in this research considered as maverick purchases. The evidence suggests that invoices with contract number are processed faster than invoices that are missing it. Only company B processed invoices without contract number quicker than those that had it. In other companies the difference between these two groups was quite significant, especially in companies A and D. In companies A and D, where matching was done efficiently, invoices missing a contract number were processed over 4 days slower. Order number does not seem to be as important for efficient processing while companies A and C processed their invoices missing it faster. Company B on the other hand processed invoices with order number quicker. In company D only four invoices were missing a contract number and therefore accurate comparison between the ones missing an order number and the ones including it could not be done. It should however be recognized that company D is matching their invoices to purchase orders and therefore it is safe to assume that due to the high amount of invoices including it, their invoice processing is the quickest of all.

The influence analyses conducted on most time consuming process steps as well as for the manual tasks and for invoices that take over 30 days to process all indicate that blank values in these invoice attributes impact an invoice to take slower paths and require changes in data. While contract number seems to be even more important, the lack of order number in some cases also prolongs the handling of the invoice. When goods and

services are purchased through appropriate channels these values are more likely to exist on an invoice, this in turn seems to boost the processing especially in the case of contract number.

The last sub question addresses the objectives companies can engage in to enhance the purchase to pay process. These suggestions are based on previous research and the state of each company's process. Key objectives are listed for each company separately.

- ***What kind of options organizations have to enhance the process and gain more value out of it?***

Company A

In company A the matching of invoices to contracts was done effectively. The volume of invoices however was not as big as with the other companies. The parts where company A could find the most improvements lie in order matching. Suggestions on how to enhance the process for company A include:

- Raising the percentage of order matched invoices through better purchasing practices
- Lowering the amount of invoices requiring comments, need for more accurate invoice information
- Invoice validation service & mobile solutions
- Possibility to leverage supply chain financing services, but no need for more extensive financial supply chain management strategies due to low amount of invoices.

Company B

Company B processed over 200 000 invoices during the examination period. While the cycle times were relatively good, there is still room for improvement, especially in matching. Suggestions for improvements:

- Raising the amount of matched invoices (in collaboration with suppliers), which is at the moment basically non-existent, with only 191 matched invoices
- Invoice validation service & mobile solutions
- Reducing the amount of maverick purchases
- Possibilities to leverage SCF services and more extensive financial supply chain management strategies.

Company C

Company C's process was very similar to that of company B and also the suggested improvements are the same. Suggestions for improvements:

- Raising the amount of matched invoices (in collaboration with suppliers), which is at the moment non-existent
- Invoice validation service & mobile solutions
- Reducing the amount of maverick purchases
- Possibilities to leverage SCF services and more extensive financial supply chain management strategies.

Company D

In company D the process is very well organized. The cycle time for invoices was arguably the best of all participants. The next step could be to engage in financial supply chain strategies that benefit the whole supply network.

- Still potential to raise the percentage of order matched invoices
- Invoice validation service & mobile solutions
- Lowering the amount of invoices requiring comments
- SFC services and more extensive collaborative financial supply chain management strategies.

The results of the research were rather surprising. The fact that two companies actually processed their scanned invoices faster was not

something the author expected. Of course, it has to be remembered that some parts of the handling of scanned invoices are not included in this examination. It could be that if those process phases are included, the results would be different. It can also be anticipated that once more companies gain the ability and resources to efficiently send and receive e-invoices the handling of e-invoices should develop and get quicker as well. Only the future will show if this becomes true.

In the light of the evidence regarding invoices from maverick purchases, it is safe to say that when purchases are made from preferred suppliers and through appropriate channels the processing of invoices is faster and consumes less resources. All the companies who participated in this research had median durations of less than one week. When most of the common due days values are over a week, it can be said that the processes of these companies are in a pretty good shape. Obviously there are some little things each company can do better. The biggest opportunities for companies, who have reached processes as quick and mature as seen in this research, lie in comprehensive financial supply chain strategies that can benefit not only the company itself, but the whole supply network they operate in. While all the companies face different supply chain environments each company has to consider whether these strategies can really offer them the promised benefits.

8. LIMITATIONS AND FURTHER RESEARCH IMPLICATIONS

This research was limited to only four companies due to the extensive nature of invoice data provided by each company. The sample was also limited to only include companies from European countries. The data that was analyzed was collected from one calendar year in order to get more reliable results. Monthly or quarterly analyses would have possibly been bias due to the long summer holidays in Finnish companies. The data was also modified to be as uniform as possible in order to gain comparable results. Therefore some process steps from each company's process were excluded from the analysis conducted for this research.

Regarding the processing of the invoice, this research only acknowledges the time invoices spend within the invoice processing solution. Manual tasks performed by humans that are related to handling of scanned invoices and occur before the invoice is scanned and created into the solutions processing flow are ignored in this research. Adding these tasks and their duration to the research would have brought the whole life cycle of both invoice types into an equal examination. This could be one option on how to broaden the scope of the research and get more comparable results on cycle times between different types of invoices. In this research the benefits of e-invoices are overshadowed by the fact that the tasks that are required for a paper invoice to get transformed into electronic format are excluded from the analysis.

At the time of taking the sample from each company's invoice processing system, all the companies had invoices that were still yet to finish processing and were somewhere in the middle of the processing cycle. There were also invoices that had been in the cycle possibly for hundreds of days and were later cancelled. It would be interesting to know if the results of the research would be different if these invoices would have been excluded from the analysis. The impact on median duration, which

was used as the primary measure of cycle times, would probably not be that big.

For further research it would be interesting to add more companies into the analysis and possibly companies from other regions such as the Americas or Asia. Also, it would be interesting to see how a company that receives 100% e-invoices would match against other companies. Another interesting issue to investigate could be what are the invoice attributes that most commonly require changes in basic data and posting data changed steps. It would be useful to know what the attribute value was before modifying and what it was changed into. This would provide insight into what attribute values are the most important in order for an invoice to get approved and paid.

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APPENDIX

Appendix 1. Influencing invoice attributes in transitions with the longest lead times

		Step 1	Step 2	Step 3	Step 4	Step 5
Company A	E-invoice	Contract number blank (39%) Due date days (10%)	Contract number blank (43%) Business unit X (11%) Currency SEK (10%) Payment term 30 days due net (10%)	S & C ID blank (40%) Business unit Y (32%) Currency EUR (24%) Payment term 14 days due net (17%) Supplier X (16%)	Contract number blank (36%)	Supplier Y (40%) Due date days 17 (39%) S & C ID blank (32%) Payment term specified date (29%) Business unit Y (29%)
	Scanned invoices	Payment date specified (13%) Currency RUB (13%) Payment term 7 days due net (13%) Due date days 7 (13%) Image file name scanner (11%)	Business unit X (20%) Currency GPB (20%) Due date days 10 (13%) Supplier Z (13%) Payment term 10 days due net (11%)	Image file name scanner (14%)	Currency GBP (11%)	Image file name scanner (14%) Payment term 30 days due net (14%) Payment date specified (14%) Business unit Y (14%)
Company B	E-invoice	Business unit X (33%) Due date days 30 (20%) Payment term 14 days - 2% 30 DN (16%)	Business unit Y (26%) Payment term net immediately (25%) Order number blank (13%) Cash discount date blank (11%)	Business unit Z (27%) Business unit X (25%)	Order number blank (11%) Cash discount date blank (10%)	Business unit X (16%) Contract number blank (11%)
	Scanned invoices	Business unit X (39%) Image file name scanner (22%) Payment term 14 days – 2% 30 DN (16%) Due date days 30 (15%) Business unit Z (15%)	Business unit Y (31%) Net sum EUR blank (17%) Cash discount date blank (15%) Image file name scanner (14%) Due date days 14 (12%)	Cash discount date blank (14%) Due date days 14 (12%) Business unit Q (10%)	No influencers	Business unit X (10%)
Company C	E-invoice	Invoice type ERP (81%) Business unit X (21%) Currency SEK (17%) Business unit Y (17%) Business unit Z (14%)	Due date days 30 (26%) Business unit Q (23%) Invoice type EV (21%) Business unit F (16%)	Invoice type EV (21%) Order number blank (14%)	Order number blank (18%) Invoice type ERP (10%)	Business unit Q (31%) Invoice type EV (24%) Due date days (21 (235) Currency EUR (15%)
	Scanned invoices	Invoice type ERP (74%) Business unit Z (31%) Due date days 30 (21%) Currency SEK (19%) Payment term 30 (11%)	Invoice type EF (25%) Order number blank (22%)	No influencers	Order number blank (18%) Invoice type EF (17%)	Invoice type EF (19%) Order number blank (17%)
Company D	Scanned invoices	Invoice status cancelled (94%) Contract number blank (46%)	Supplier X (9%)	Payment term blank (11%)	Payment term blank (16%)	Contract number blank (6%)