Master's Thesis

Jenni Lunttila

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DIGITAL SIGNATURE: ADOPTION, TECHNOLOGY, COSTS & BENEFITS

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Author: Jenni Lunttila

Supervisor / Examiner 1: Mikael Collan

Examiner 2: Jere Vento

ABSTRACT

Author:	Jenni Lunttila
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Nowadays in our globalized world business partners can be on the opposite sides of the globe. Through the development of technology, the location is losing its importance as working remotely becomes increasingly popular. Additionally, with the ever-growing knowledge of our environment the paperless solutions become more common.

This study focuses on offering one solution how to optimize signing which is a part of administrative processes. Signing documents the traditional way by hand can be extremely inefficient and time consuming. Here electronic signatures allow people to sign documents efficiently regardless of their current location.

This study consists of introduction to current and past legislation around electronic signatures in United States, European Union and Finland. It is followed by the literature review state of art of e-signature studies. These studies focus on the technology, benefit and adoption research of e-signatures. The Lazy User Model (LUM) is also presented and discussed in the context of e-signatures.

The main findings of this study support the ideas of LUM. Through adoption of e-signatures users are able to focus on their actual tasks. The costs from the adoption of e-signatures can be thought as an investment to efficiency obtained through laziness.

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Nykypäivän kansainvälistyneessä maailmassa liikekumppanit saattavat olla maapallon vastakkaisilla puolilla. Teknologian kehityksen myötä fyysisen sijainnin merkitys heikkenee etätyöskentelyn suosion samanaikaisesti kasvaessa. Tämän ohella ympäristötietoisuuden lisääntyessä paperittomat ratkaisut yleistyvät.

Tämä tutkielma keskittyy erityisesti tarjoamaan ratkaisuehdotusta optimoidaksemme allekirjoittamisen, joka on olennainen osa hallinnollisia prosesseja. Asiakirjojen allekirjoittaminen perinteisesti käsin on äärimmäisen tehotonta sekä aikaa vievää. Tähän sähköiset allekirjoitukset tarjoavat mahdollisuuden allekirjoittaa dokumentteja tehokkaasti allekirjoittajan sen hetkisestä sijainnista riippumatta.

Tämä tutkielma koostuu johdannosta vallitsevaan ja menneeseen lainsäädäntöön sähköisten allekirjoitusten ympärillä Yhdysvalloissa, Euroopan Unionissa sekä Suomessa. Seuraavana kirjallisuuskatsauksessa esitellään aiempia tutkimuksia sähköisten allekirjoitusten teknologioista, hyödyistä sekä käyttöönotosta. Lazy User Model (LUM) esitellään ja sen ideoita käsitellään sähköisten allekirjoitusten kontekstissa.

Tutkielman keskeisimmät johtopäätökset ovat yhteneväisiä LUM:n kanssa. Käyttämällä sähköisiä allekirjoituksia käyttäjille jää enemmän aikaa keskittyä varsinaisiin tehtäviinsä. Käyttöönoton kustannukset voidaan ajatella investointina laiskuuden kautta saavutettavaan tehokkuuteen.

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First of all, I wish to express my gratitude to professor Mikael Collan for all his guidance and support during my studies at LUT, since the most valuable thing a person can give to another is time. I hope to continue this co-operation through my ongoing studies in the field of Business Analytics. Thanks to him, I'm also pursuing that truly interesting second degree. I also wish to pay my gratitude to my other examiner Jere Vento.

By the threshold of graduating with an economics degree, I've been wondering what I've actually learned during five years of academic studies. I came to the conclusion that I have learnt how to question things, how to ask why something is the way it is, and whether it be done differently. Most of all, I've learnt how much more there is still to learn.

Whilst working on this study, I got familiarized with the Lazy User Model. Interestingly, I found myself thinking everyday actions in the light of that theory.

Finally, I want to thank my parents, grandma and grandpa for their support in many ways, and most importantly for believing in me. I also appreciate my friends who have beared with me talking about my thesis and offering me counterbalance for studies.

Jenni Lunttila

18.2.2019 in Kuopio

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LIST OF ABBREVIATIONS

CA	Certificate Authority
eIDAS	Regulation (EU) No 910/2014 of the European Parliament and of the Council of 23 July 2014 on electronic identification and trust services for electronic transactions in the internal market and repealing Directive 1999/93/EC
E-Sign Act	Electronic Signatures in Global and National Commerce Act
e-signature	Electronic Signature
EU	European Union
ICT	Information and Communication Technology
LUM	Lazy User Model
MLEC	Model Law on Electronic Commerce
MLES	Model Law on Electronic Signatures
PKI	Public Key Infrastructure
UETA	Uniform Electronic Transactions Act
USA	United States of America
Utah Act	Utah Digital Signature Act

1 Introduction

1.1 Background of the study

Analytics, and especially analytics aiding decision-making, is one of the hot topics in the modern business world. Another characterizing feature is the constant feeling of hastiness. There seems to be more things to do than there is time available. Irrelevant errands eat up enormous amounts of people's days leaving little time for actual value creating tasks. This thesis focuses on introducing one possible solution to this puzzle. Like a good statistician, people need to learn how to be lazy. Laziness demands for creative solutions. This ultimately allows people to focus on their fundamental tasks and minimize the time wasted.

Imagine a situation where your business partner is at the opposite part of the world and you need them to sign a document in order to continue your business processes. Without possibility to sign electronically you would need to send the contract by email or in the worst case mail it, and not knowing when your partner will receive this document. Also, this traditional way increases the risk of losing the document. Here, electronic signatures (hereinafter e-signatures) offer a solution to speed up the processes in a secure manner. This way e-signatures could remove the final bottleneck of business and retail.

In legal terms, signature verifies that the signed document is in-line with the signee's will or intentions (Meriam-Webster 2018). This could be done through the traditional way of printing out the document, then signing it by hand and finally scanning the document back to the electronical form. The other way, the efficient way of performing the same task is to use e-signatures.

As Adobe (2017), one of the world's largest companies focusing on producing digital content, states "without a fully digital business, the greatest risk is being left behind". That's one of the many reasons why e-signatures are in a key role in today's business world which is in the middle of digitalization. Through usage of e-signatures some major benefits can be gained. The purpose of this study is to identify those benefits, especially in the field of accounting. To be precise, our interest lies in the possible benefits of e-signatures in efficiency and convenience for user. The soon to be change in the Payment Service Directive (PSD2) enhances the relevance of the topic of this study. Digitalization accelerates the pace of transactions which then demands more flexible solutions where the e-signatures offer an answer.

As the eIDAS (910/2014, IDentification, Authentication and trust Services) states, trust and particularly trust in online environment is crucial for successful development of social and economic areas. According to the report by U.S. Department of Commerce (2018a) the estimated value of nation’s retail e-commerce transactions for the year 2017 was $453.5 billion dollars which is about 8.9 percent of the total retail sales value. For this year, they have predicted the percent value of e-commerce of all retail sales to grow totaling over 10 percent (2018b). E-commerce includes all commerce which takes place in an online environment varying from ordinary consumers’ online shopping to business transactions between companies. Also, due to these huge, increasing volumes we need to learn how to obtain this needed trust.

Initially e-signatures’ linkage to the field of accounting might be difficult to seize. Although accounting is traditionally observed falsely only as bookkeeping and recording financial transactions, it is much more than merely the cost side of accounting. It is also the activities to gather information to shareholders while providing guidance to management. As our degree is described by LUT University (2019) on its website: Accounting is about the idea to grasp the overall view on corporate functions and financial management at the same time considering the challenges posed by ever-changing business industry.

However, there are not many previous studies around this topic as we can later see in the literature section. Thus, we can observe the research gap which creates demand for this kind of study. It’s critical to remain task-centric: What questions need to be answered? What data is needed to answer those questions? To whom this kind of research is focused on?

1.2 Focus and research questions

The information systems play a crucial role in all corporate business transactions these days. Here, the e-signatures come to play. They ease the work required in both every day and business life. They allow focus to be directed to core functions, thereby eliminating unnecessary chores. In essence, this thesis is about optimizing a crucial part of an administrative process which is authorizing by signing. Without legislative authorization that signatures provide almost all transactions would become void and eventually business would come to a halt. Figure 1 below shows the focus of this study and the relation of the topic to field of accounting.

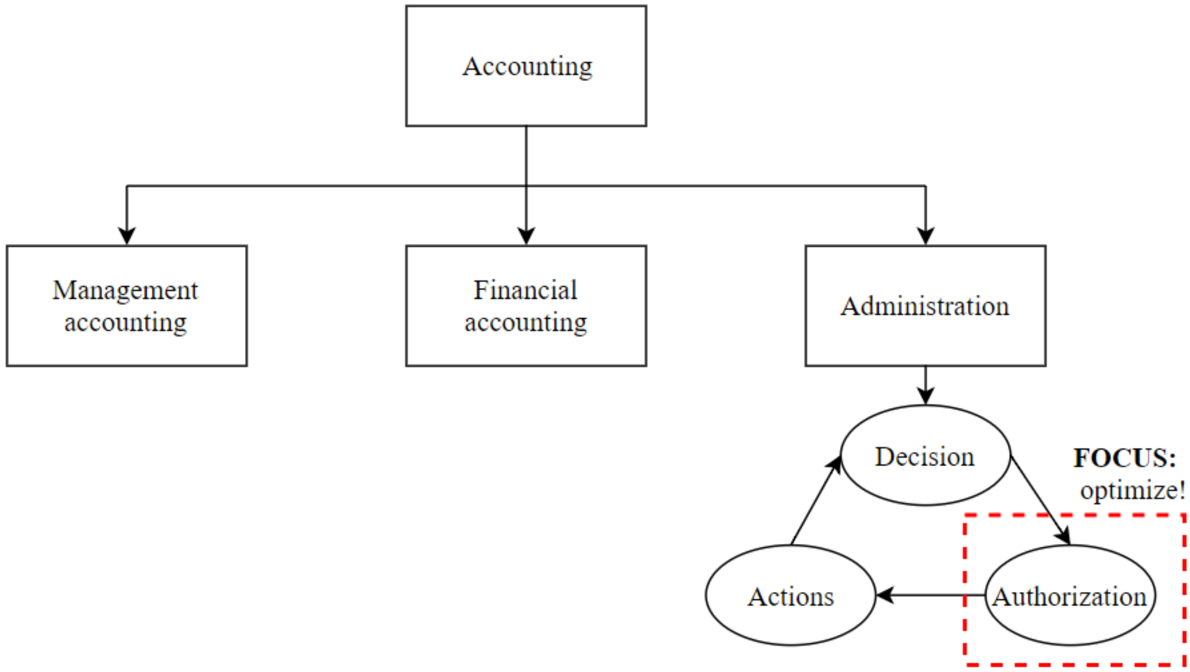

Figure 1. Relation to field of accounting.

Due to broadness of this topic some topics have to be left out from further examination. Outside of the scope of this study are left out the broad risks of digitalization and the social negative side effects of digitalization. Further examination of the mathematical and technical details behind different encryption methods are also left out. Likewise, the possible depreciations of the investments are disregarded of the discussion. Keeping the focus of this study clear through the whole thesis is crucial. This study aims to provide answers to optimization of signing which is a crucial phase of almost any administrative processes.

Based on the focus, we formulate the research questions. The sub-research questions together help us to form an answer to the main research question. This main research question shows the object of this study in a question form. The first sub-research question is answered in the legislative section in introduction. The second question focuses on presenting previous studies around e-signatures and their benefits. The third one calls for answers to the overall utility of e-signatures. Last sub-research question is about the adoption of e-signatures. More closely we try to provide description of a good and easy-to-use e-signature system. Finally, the main research combines the previous questions into one. This is shown question last in the list below after the figure 2. All in all, the questions are answered in a logical order as the text proceeds. The relational layout of my research questions can be seen from the figure 2 below.

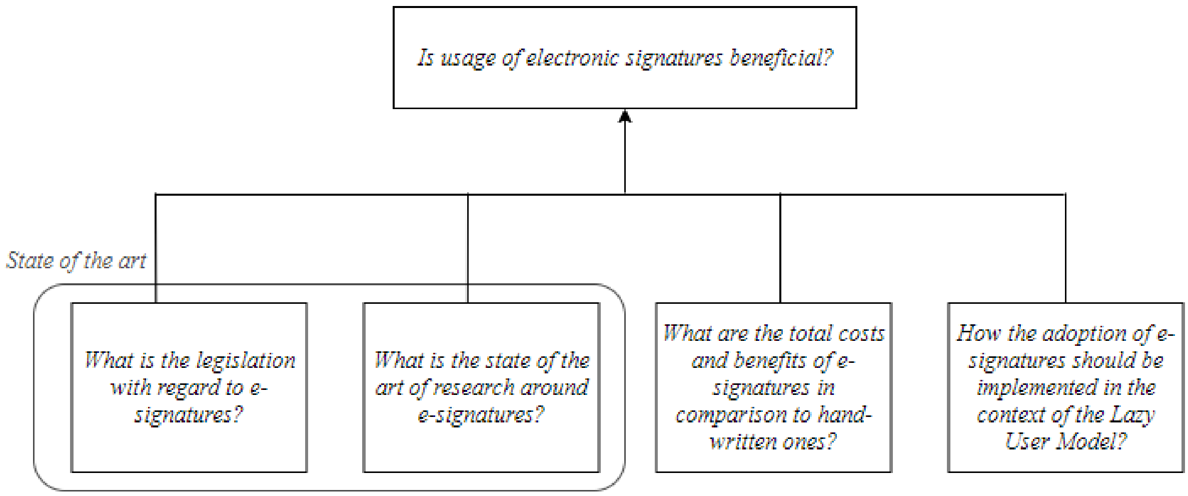

Figure 2. The relationship between main and sub-research questions.

This study aims to answer to the following research questions:

What is the legislation surrounding e-signatures?

What is the state of the art of research with regard to e-signatures?

What are the total costs and benefits of e-signatures in comparison to hand-written ones?

How the adoption of e-signatures should be implemented in the context of the Lazy User Model?

Is usage of electronic signatures beneficial?

1.3 Structure of the study & research methods

This section will briefly describe the contents of each of the following chapters. We shall also cover the research methods used to conduct this study. The figure 3 below demonstrates the theoretical framework for the state-of-the-art of this study. We begin by defining and presenting legislation around e-signatures. The focus is on US, EU and Finnish legislation. This legislation lays the foundations for the other parts. Then, it is followed by the overview to previous literature around this topic in chapter 2. That section has three sub-sections each having more sub-chapters. We will cover technical literature, research of the benefits and finally, adoption research.

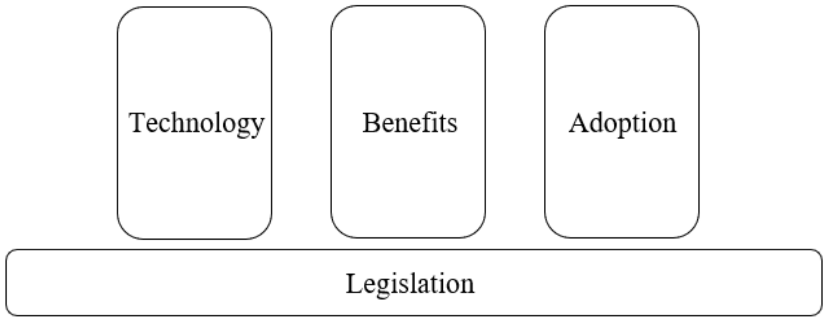

Figure 3. The framework of state-of-the-art literature.

After reviewing the previous literature around this topic, we expand to the empirical section as can be observed from the figure 4 below showing the structure of the whole study. Empirical section is also carried out in three parts. Finally, we conclude this thesis by giving answers to our main interests about the benefits of usage of e-signatures and the demands for practical and functional e-signature platforms. Here productivity and user experience are our key interests per to the focus. Main focus is on legislation in Finland, EU and USA, technical background and resource benefits in business. Each section is linked to each other, so helping to preserve the coherence and overall readability.

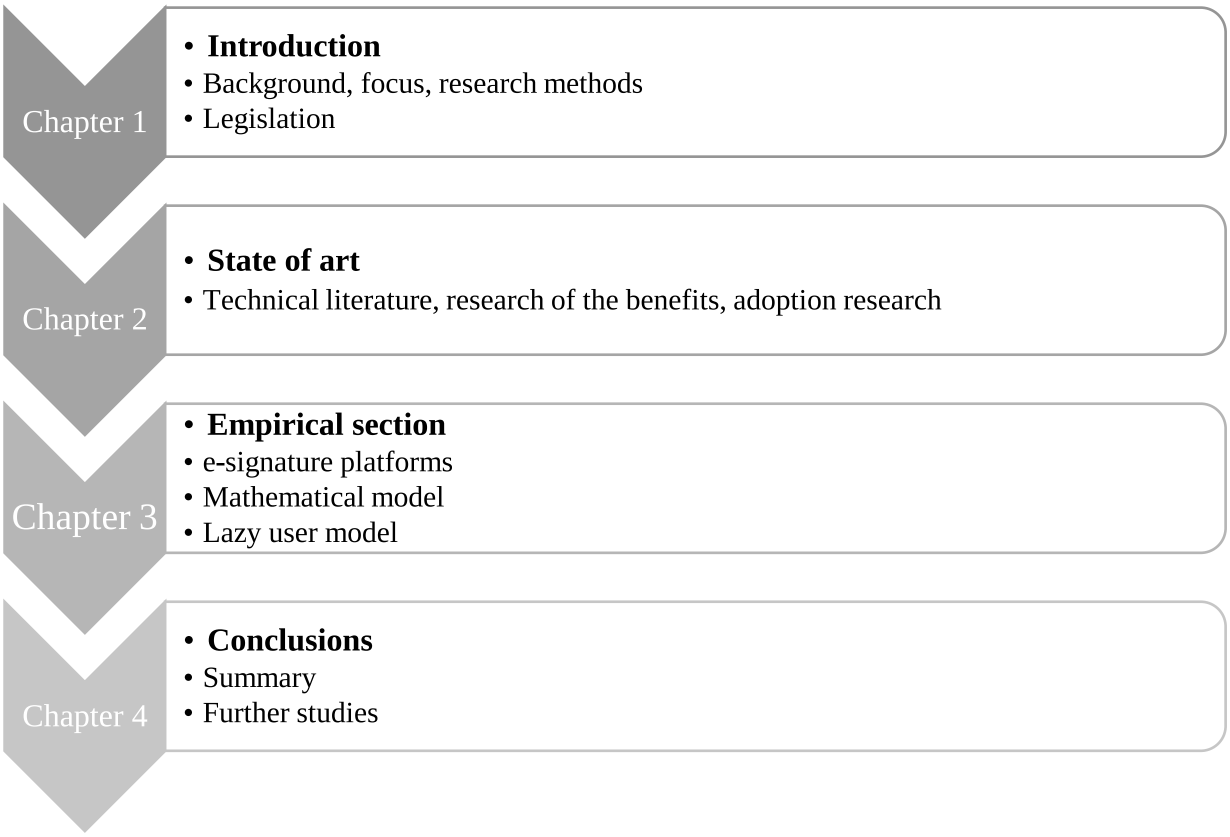

Figure 4. Structure of the study.

The first two sub-research questions are answered through a literature review. This consists of legislative texts from USA, EU then Finland, and state-of-the-art studies around e-signatures. Literature review is performed both to gain knowledge on the current state of e-signature studies and to expose the research gap in that area of study. The search process for articles form different databases is described in more detail later in chapter 2 Literature review – state of the art of e-signature studies. Rest of the research questions are answered in the following sections.

Initially, the empirical section was supposed to be carried out through analysis of user data. Due to some difficulties on attaining those records, the structure of that section altered. Eventually, the empiric part is composed on comparison of e-signatures with the paper one. There different situations are considered while presenting various e-signing solutions. Remarks from the solutions are then discussed in the context of Lazy User Model by Collan and Tétard (2011). The actual model is briefly introduced later in chapter 2.2.3.1 Lazy User Model.

1.4 Legislation

In this section, main points of the legislation around e-signatures in United States of America (hereinafter USA), European Union (hereinafter EU) and Finland is presented. Finnish law is chosen as a specific object of interest for the sole reason that I am a Finn, and this thesis is done for a Finnish university. EU legislation is applied to national level in its member states to which Finland belongs. USA's E-Sign Act together with the Uniform Electronic Transactions Act affects globally and that is why its shortly presented below. Later differences between E-Sign Act and eIDAS are presented shortly. Globalization and world trade create a demand for international legal standards especially to the field of contract law.

With unification of internal market, a single digital market could be created. Integration of legislation would for its part then promote spread of technologies and finally enhancement of administrative processes. Ultimately this would lead to more efficient market economies and economic growth. On paper this sounds fine but there are some difficulties in the practical implementation. In US there are legislative differences between the states, whereas similar situation in EU is between member nations. For example, in Poland, which is an EU member state, e-signing of contract of employment is not legally binding while in Finland it is as legally binding as a contract signed by hand. This illustrates that despite directive legislation on EU level does not solve national dissimilarities.

In June 1996 United Nations Commission on International Trade presented a Model law on Electronic Commerce (hereinafter MLEC). This model law was supposed to promote international e-commerce by providing guidelines to remove possible legal obstacles and to enhance legal predictability. MLEC was first to establish the ground rule of e-signature legislation. Under chapter II in article 5 it states as (its) non-discrimination policy as follows; “Information shall not be denied legal effect, validity or enforceability solely on the grounds that it is in the form of a data message.” Here data message refers to all information generated, sent, received or stored in electronic, optical or other similar means.

Later in 2001 MLEC was followed by Model Law on Electronic Signatures (hereinafter MLES). MLES answered to the unresolved questions about e-signatures left open after MLEC. It clarified the fact about e-signatures being as legally binding as hand-written ones. Along with non-discrimination policy, other essential concepts presented by MLEC and specified by MLES are technology-neutrality and functional equivalence. These all are the fundaments of e-signature legislation today enabling business transformation to a whole new level.

1.4.1 US legislation

Utah Digital Signature Act (Utah Code § 46-3-101 et seq., hereinafter Utah Act) allowed Utah to be the first US state to adopt Public key infrastructure (PKI) based digital signature statute in 1995. Utah was also one of the first governments to give legal recognition to digital signatures. Technical details about PKI identification methods is later discussed in more detail in state of art literature review. However, Utah Act was repealed in 2006. One of the reasons for this was that the act put excessive amount of risk onto the signer. Other problem of the Utah Act was that it defined digital signatures to be only encrypted using asymmetric encryption techniques.

Electronic Signatures in Global and National Commerce Act (hereinafter E-Sign Act) entered into force on October 1, 2000 in USA. The goal of this act was to promote e-commerce by enforcing consumer trust on transactions over the Internet and ease national and international trade through electronical contracts. The act states that electronic form of any signature, contract or other legal record cannot be a reason for denying its legal effect, validity or enforceability in interstate and foreign commerce.

Around the same time with E-Sign Act, the National Conference of Commissioners on Uniform State Laws (NCCUSL) proposed the Uniform Electronic Transactions Act (hereinafter UETA) as one of the United States Uniform Acts in 1999. The act was enacted next year, in 2000 by the Virginia General Assembly. Its purpose is to harmonize different state laws about retention of paper records, especially checks, and the validity of e-signatures. This act applies only to those records and e-signatures affiliated with transactions. Basically, E-Sign Act covers e-signatures in broader manner than UETA, but they both have a similar target which is to by legalizing e-signatures to facilitate e-commerce.

1.4.2 EU legislation

In 1999 EU Directive for Electronic Signatures (1999/93/EC) was entered into force. Five national transpositions were made in Finland according to this EU directive. These acts are introduced in greater detail in following a sub-chapter below. Main purpose for the e-signature's directive was to permit the use of e-signatures in electronic contracts within the EU and to establish a legal framework for them. For the cause of clarifying the contents of the directive 1999/93/EC the concepts of electronic signature and advanced electronic signature are explained as follows. Data in electronic form attached to or logically associated with other electronic data is considered to be an electronic signature which serves as a method of authentication. Electronic signature becomes advanced when it fulfills four specified requirements. E-signature ought to be (1) uniquely linked to the person signing, (2) capable of identifying the signatory, (3) created using means which the signatory can fully control, and (4) linked to the data so that any alteration of the original data is detectable.

Later in June 2016 directive 1999/93/EC was repealed by Regulation 910/2014 of the European Parliament and of the Council of 23 July 2014 on electronical identification and trust services for electronic transactions in the internal market. This regulation is commonly known and later referred as eIDAS which is an acronym from the regulation's name electronic IDentification, Authentication and trust Services.

Object of this regulation is to make internal markets more effective and transactions on the Internet more secure by improving trust in e-transactions. Starting from September 29, 2018 electronic identification issued in one EU member state must be recognized in all other EU countries and all organizations delivering public digital services in one.

Considering the legal perspective, the article 25 'Legal effects on electronical signatures' in section four 'Electronic Signatures' turns out to be interesting and crucial. The article states that any electronic signature cannot be denied legal affect and admissibility as evidence in the eye of law just because that it is in an electronic form or it does not fulfill the criteria for qualified e-signatures. This means that any electronic signature is as legally valid as handwritten one. Article also notes that because of the union a valid electronic signature in one of its member states is therefore valid in all of the others as well.

Until May 24, 2018 processing of personal data was carried out according to EU Directive 95/46/EC of the European Parliament and of the Council of 24 October 1995 on the protection of individuals with regard to the processing of personal data and on the free movement of such data. Now, EU Regulation 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data. This regulation is generally known as GDPR (General Data Protection Regulation). The most critical addition to GRPR in addition to the old directive is that it concerns all organizations also outside EU that process personal data of EU citizens as mentioned in article three. Regulation also poses great responsibilities to all parties handling personal data. Main objective of this regulation is to protect citizens' privacy and rights. GDPR allows data usage only for a focused purpose. This causes possible legislative issues on combining and reusing data.

1.4.3 Legislation in Finland

As an EU member state Finland must follow EU regulations in its national legislation. The Act on Electronic Service in the Administration (1318/1999) adopted at the turn of the century is considered to be the beginning of making digital services equal to 'traditional' non-digital ones in the eyes of law. Its purpose was to make administrative tasks more fluent and secure by allowing electronical data transmission of necessary documents. Before that the Act on Electronic Data Interchange and Automatic Data Processing in the General Courts (594/1993) eased legislative processes by allowing delivery of documents also via fax or email.

Both of these acts were repealed by the Act on Electronic Services and Communication in the Public Sector (13/2003) which combined those acts into a single law. This act was then later altered with minor changes to adopt to the new technologies and alterations in the environment. In 2009 (618/2009), signing concluding documents electronically was made legally valid using strong identification methods. Earlier, only some documents like application for a summons were allowed to be signed electronically. Most recent addition in 2016 (534/2016) allowed the usage of electronic documents without traditional signature as legally binding as documents on paper with a handwritten signature. This conforms to the eIDAS. The method used for this ought to be fulfilling the demands posed by EU in order to be curtain of the integrity and identity of the document.

The act on Electronic Signatures (14/2003) was first adopted in 2003. E-signatures which can be unequivocally be used to identify the person signing and which are made using a certificate fulfilling EU's requirements are at least as legally binding as traditional signatures. This act was then later repealed by the Act on Strong Electronic Identification and Electronic Signatures

(617/2009). Act states the requirements for validating e-signatures, and the responsibilities for provider of identification services.

Today, the current prime minister Juha Sipilä’s government program (2015, 26) states the digitalization of public-sector services as one of its flagship initiatives. This creates pressure for transformation for administrative structures and poses some demands for legislation. Digitalization is something we cannot afford to ignore in order to survive in modern global markets.

1.4.3.1 Tupas – former identification service

Currently in Finland there are about 400 million online bank identifications per year. In Finland in 2016 Tupas used for 69,3 million transactions and mobile certificate only for less than 2 million transactions (HE 83/2017). Costs for strong identification yield up to about 109 million per year from which majority comes from usage of electronic identification services, which is around 72 million euros. Others are initial identification, distribution of tokens and maintenance of identification service. (HE 74/2016)

Until year 2019, in Finland Tupas interface is used for strong identification for online services. Tupas is an abbreviation of Finnish words Tunnistuspalvelustandardi which means identification service standard. Customers used their bank identifiers to verify their identity. Nowadays there is a need for international system solutions. Additionally, the technology behind Tupas is outdated, and people without bank identifiers can’t use Tupas interface for online identification.Provision 72/2016 on Electronic Identification and Trust Services was issued in 2016 to specify the contents of the Act 617/2009 and eIDAS. During 2018 Viestintävirasto (Finnish Communications Regulatory Authority) makes the transition from provision 72/2016 to provision 72A/2018 to conform to the demands set by PSD2. The provision 72A/2018 was issued in May 2018. Their intention is to enhance the identification services’ information security.

Both provisions 72/2016 and 72A/2018 are supplementary to the EU legislation, eIDAS. They provide more detailed criteria for certification of e-signature services and evaluation of independence and proficiency of trust services. Their main goal is to enhance information security and technical interoperability of strong identification services. Provisions demand that the identification systems have to be conducted in a way that its pays attention to systems communications security, information system security and operability security.

Both provisions require that for RSA encryption method the key length has to be at least 2048 bits. If ECDHE method is used, size of the finite field for calculations has to be at least 224 bits. Hash function used for encryption can be either, SHA-2, SHA-3 or Whirlpool. By setting these minimum requirements, the security of e-signature systems is tried to guarantee. Little insight about these encryption techniques and few others is provider later in the first part of the state of the art literature review.

According to Viestintävirasto provision 72A/2018 was made to extend the deadlines for transitions. It demands needed technical changes in full for interfaces in order to fulfill the personal data security requirements to be done by October 1, 2019. This date was postponed by Viestintäministeriö (Finnish Ministry of Communications). This postponement of the transition time is meant to ease and enhance the systems development for the banks. October 2018 those technical alterations have to be planned at the latest. Trust circle gets the access to those altered interfaces at the latest on March 1, 2019. (Viestintävirasto 2018)

As a solution, Finnish government proposes (HE 83/2017) that Act 617/2009 should be changed so that the pricing of identification services would be more moderate. Currently Tupas is expensive and there is no real possibility for competitive tendering (HE 74/2016). Until the May 2017 standard price per identification transaction using Tupas was 0,50 euros. With the alteration to the act 617/2009 the price drops to 0,10 euros to which the transmission server can add up its personal fee.

The new amendment to the act 617/2009 also eases the work for service providers. There is no longer need to form a separate contract with all the different banks. (617/2009) This change enables interoperability of different identification and service providers, and therefore lowers the costs. Before that the service provider had to make a separate agreement with all the whose Tupas interface it wanted to use for identification. Because of the costs of those agreements, some banks left outside causing inequality to possible clientele.

1.4.4 Differences in legislation

In this chapter, the differences and similarities between EU and US legislation are presented. The differences I noticed comparing these two acts myself are brought forth together with some notes from academic literature around this topic. The first clear difference between these two acts is that eIDAS treats member states in almost the same way as E-Sign Act individual states.

Both acts clearly state the legal grounds for signatures in electronic form at the very beginning of the legislative text. Electronic form of a signature or a contract cannot be used as an excuse to not consider that as legally binding as hand-written one. The acts emphasize the importance of trust for online transactions and possibility of international ecommerce through harmonization of legislation.

Both eIDAS and E-SIGN Act emphasize the importance of promoting international e-commerce. According to E-Sign Act (sec. 301) removal of paper-based obstacles, appropriate authentication technologies and non-discriminatory approach to e-signatures is a key to achieving that goal. It focuses on B2C transactions (Bell, J., Gomez, R., Hodge, P. & Mayer-Schönberger, V. 2001). eIDAS is more broadly applicable than E-Sign Act. It focuses more on developing e-commerce in internal market first before entering into external markets. However, eIDAS encourages to use international standards in trust services to ease the process of becoming global.

eIDAS focuses on building trust in e-commerce on EU's internal market. This can be achieved through high level of security, transparency of both politics and policies, and co-operation between member states. It is meant to unify electronic identification services in member states. Through this conformation the electronic barrier between nations will be removed allowing mobility of data be as in single great nation. eIDAS asks for technology-neutrality, security co-operation and technical interoperability to ensure this, and uniform conditions regardless of the geological location. E-Sign Act does not mandate the type of technology to be used but it controls the actual usage of e-signatures (Bell, J. et al. 2001).

eIDAS states in article 11 that the data protection is to be done in accordance with the GDPR (Directive 95/46/EC). Cause of this practice is still quite new, in the long run the consequences of GDPR to e-signatures is still bit unclear. GDPR affects also companies outside EU which offer services to EU nations. This change demands for deep legislation knowledge (Stalla-Bourdillon, S., Pearce, H. & Tsakalakis, N. 2018).

E-Sign Act focuses on building trust and consumer protection by stating few exceptions when e-record is not enough to obligate legally. Under section 103 some of these exceptions are listed. In the case of court orders, official court documents, eviction notice, cancellation or termination of health insurance, and license to transport or handle toxic materials document only in electronic form is not valid. These are only a few of the exceptions listed in the act for the protection of consumer rights.

The actual legislative text in eIDAS focuses on identification and authentication of the signatory and the qualification of the trust service providers. This makes it possible to ensure the confidentiality of e-signatures. From this ground eIDAS poses many obligations to member states' supervisory bodies. One of these liabilities is to act according to EU's instructions if security breach happens to happen affecting reliability in cross-border authentication. E-Sign Act has its focus on electronic form itself. eIDAS lists the requirements for both "normal" and advanced e-signatures. In eSign Act only the electronic form of the signature is mentioned.

Penalties from breaking the e-signature law by eIDAS is determined by each member state separately. However, e-signature will lose its validity if it has been revoked after its initial activation. Revoked from its validity, e-signature cannot receive its qualified certificate anymore. As an exception, temporary suspension of certificate is plausible.

eIDAS states detailed requisites for trust service providers. This way EU trust mark truly indicates the required qualification. Trust service providers have the responsibility over the possible damage caused by negligence of following the instructions. According to eIDAS for electronic seals the requirements are the same as for e-signatures (*mutatis mutandis*). Also, same contents but shorter for electronic time stamps, electronic delivery systems and website authentications. Requirements listed in the annexes are meant to guarantee the preservation of the confidentiality of e-signatures and protection of personal data.

E-Sign Act excludes oral communications as electronic records in the face of law. However, electronic sound can be considered as an e-signature. eIDAS accepts audiovisual material as a legally binding digital record. eIDAS notes that the e-signature services must be executed in such a manner that people with disabilities are able to use those. E-Sign Act (sec. 401) makes an amendment to the Child Online Protection Act. This amendment basically forbids Commission from taking bribes. However, this law was never enforced. eIDAS does not editorialize this topic.

eIDAS provides more detailed definitions and goes through with a wider scope the e-signature technologies than US legislation. All in all, eIDAS is more elaborate and explicit, whereas eSign Act is at macro level and presents its points shortly. In my personal opinion the development of relevant technologies could be seen by comparing these two acts keeping in mind the time gap of 16 years between these laws. Finnish law was structured in a similar manner to EU legislation whereas US legislation seemed odd at first sight.

2 Literature review – state of the art of e-signature studies

This state of the art is trifold. First, the underlying encryption technologies are presented. It's followed by a short overview to the research on the possible benefits on e-signature. Final section of this state of the art is about the studies on adoption of e-signatures. This way we can get a good overall picture of the field of digital signature in academic studies. The main focus is on studies which are closely related to the topic of this thesis. In this section, we are trying to find some common research problems. But because of the existing research gap on this specific topic of benefits linked to e-signatures some other related studies are used for this state of the art.

I conducted this state-of-the-art section by searching for studies from Emerald Journals, Scopus, ScieneceDirect and EBSCO – Business Source Complete databases. I defined the key words for search process to find relevant previous literature from my own personal knowledge and the minor initial research I conducted on the basis of this thesis. After limiting the search and obtaining easily handled amount of papers, I scanned the search results quickly by their title and introduction in order to find relevant articles to this state-of-the-art section. The figure 5 shows the search process in Scopus and figure 6 from EBSCO Business Source Complete. In addition, I came across with some of the selected articles through other ways. The table 1 states the main articles selected for the state of the art literature review. As we can observe, there is a research gap for this kind of a study.

From Scopus I started the search with the search term "e-signature" which gave me 192 results. Then I narrowed down the results by giving another entry "biometric". After this, I got 17 hits which can easily be skimmed through to pick out relevant articles to serve my purpose. In the following figure 6 as stated above, the search process from the EBSCO Business Source Complete database can be seen. There I started with the keyword "electronic signature" which resulted in 2,600 hits. From there I first narrowed down with the word "digital" and I got 1,793 hits. To narrow the search even further down, I limited the search to only include peer-reviewed articles from academic journals with full text available and written in English. After these operations, I still had 406 hits. Then I added the search word “adoption” and got 7 hits to skim through.

The right branch in the same figure 6 illustrates another search process from EBSCO Business Source Complete. There again the first search operation is the same as earlier (“electronic signature”). With the added keyword “adoption”, I got 81 hits. By including only peer-reviewed articles form academic journals with full text available, I was able to get 9 hits for further examination.

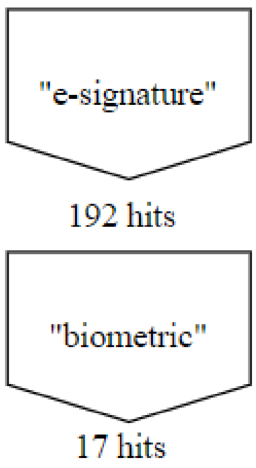

Figure 5. Search process from Scopus.

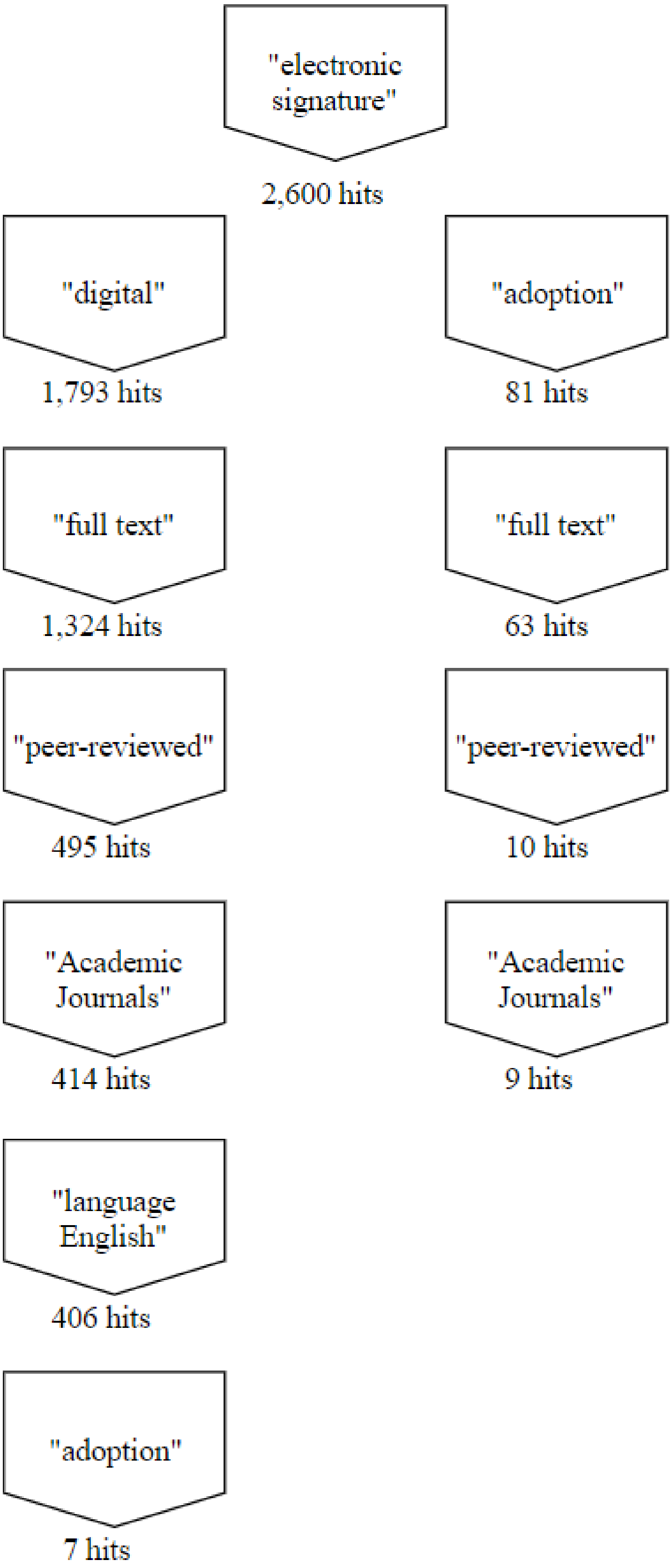

Figure 6. Search process from EBSCO Business Source Complete.

Table 1. The main articles selected for the literature review.

Author(s)	***Year***	***Name of the publication***	***Archive***
Collan, M. & Tétard, F.	2007	Lazy User Theory of Solution Selection	iadis
Chang, I-C., Hwang, H-G., Hung, M-C., Lin, M-H. & Yen, D. C.	2007	Factors affecting the adoption of e-signature: Executives' perspective of hospital information department	ScienceDirect
Galdi, C., Nappi, M. & Dugelay, J-L.	2016	Multimodal authentication on smartphones: Combining iris and sensor recognition for a double check of user identity	Scopus
Chang, I-C., Hwang, H-G., Hung, M-C., Lin, M-H., Yen, D. C.	2007	Factors affecting the adoption of electronic signature: Executives' perspective of hospital information department	ScienceDirect
Jain, A., Hong, L. & Pankanti, S.	2000	Biometric Identification	Scopus
Srivastava, A.	2011	Resistance to change: six reasons why business don't use e-signatures	Scopus
Collan, M. & Tétard, F.	2011	Lazy User Model: Solution Selection and Discussion about Switching Costs	Springer-Link

2.1 Technical literature

Both E-Sign Act (2000) and eIDAS (910/2014) define the concept of e-signatures. From E-Sign Act in section 106 the definition is as follows: "The term "electronic signature" means an electronic sound, symbol, or process, attached to or logically associated with a contract or other record and executed or adopted by a person with the intent to sign the record.". Whereas eIDAS denotes almost similar explanation for the term under the article three: "electronic signature means data in electronic form which is attached to or logically associated with other data in electronic form and which is used by the signatory to sign".

There might occur some confusion around different signature related technical terms. For example, what is the difference between electronic and digital signatures. To clarify this, lets define some key concept which are later used in this thesis. Electronic signature, or e-signature is a hypernym for various kinds of signatures in some electronic form. E-signatures are therefore technology-neutral. Digital and biometric signatures are both hyponyms of electronic signatures. Meaning that all digital and biometric signatures are e-signatures but not vice versa. This relationship is presented visually below in figure 7. Digital signatures are technology-specific, and they use public key cryptography. Whereas biometric signatures based on the idea of electronically retain physiological character of a user (Wright 1996).

In this chapter, we are going to look closer to different e-signature technologies and how those have evolved. Then, the basic idea behind Public Key Infrastructure is presented. At the end of this chapter, the other area of e-signature applications, biometric signatures are addressed. In biometric recognition on the focus are facial recognition, fingerprint and DNA. However, given the breadth of all the possible techniques, an exhaustive list of techniques is beyond the scope of a single thesis. That is way also a relevant subset of the tools available for e-signatures is presented briefly. Deeper knowledge on these techniques is also left outside of the scope of this accounting thesis.

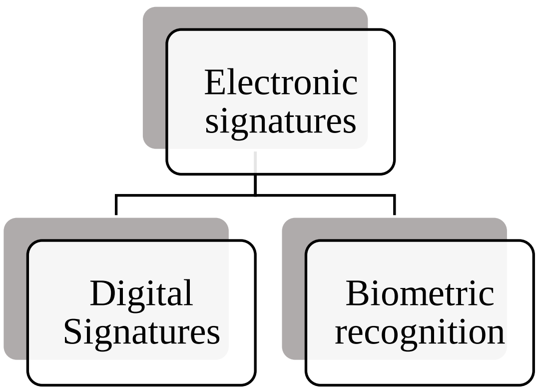

Figure 7. E-signatures.

2.1.1 Digital signatures

Rompel (1990) says that one-way functions are essential for building secure signature schemes. These are encryption functions which are simple to compute but challenging to invert. Later discussed trapdoor functions are a one type of one-way functions. With trapdoors the inversion process is made easier by providing a “secret key”. Through development of cryptographic technologies and amplified computational capabilities, the increase in efficiency can be achieved.

2.1.1.1 Public Key Infrastructure

Digital signatures are based on applying a hashing algorithm to the document. After hashing the document is then encrypted with the signer’s private key. The figure 8 below demonstrates the process of signing using digital signatures. User gives the document to the digital signature solution. Then user’s identification is verified using both the user’s own private key and the public key. As a result, the system delivers the digitally signed document back to the user. (Goswami et al. 2014)

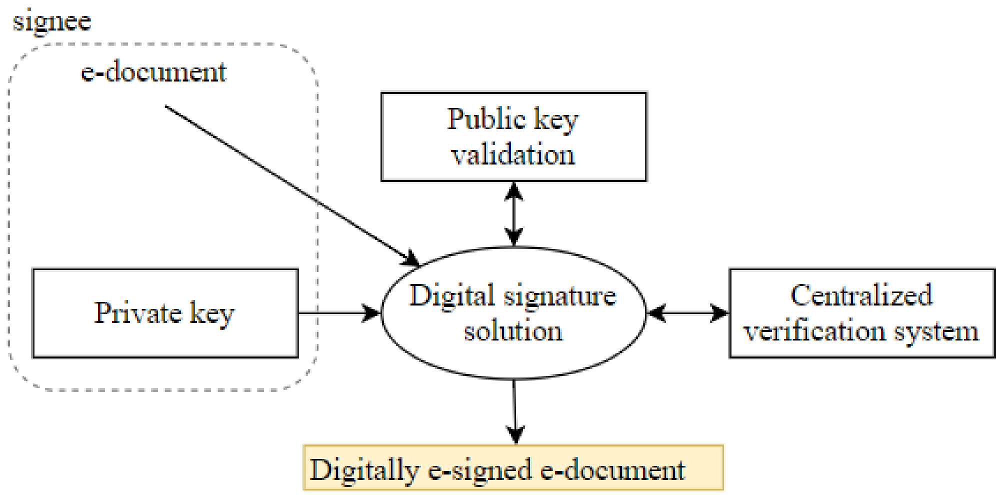

Figure 8. Digital signature process (after Goswami et al. 2014).

In public key infrastructure (hereinafter PKI) the protection of keys to assure the security is essential. Third-party organizations called Certificate Authorities (hereinafter CAs). Their job is to create, conduct and save the key and thereby protect the integrity of signatures created. The risk of forgery or other mischief grows without proper protection. CAs can provide necessary digital certificates which contain the public key and the identity related with it. These certificates are used to confirm that a certain organization has a specific public key. CAs also check and verify the identity of a person requesting a key pair. (Goswami & Misra 2014; Bankhouse 2002)

2.1.1.2 Other encryption methods

Trapdoor functions

Diffie and Hellman (1976) emphasize protection of privacy in cryptography. In their paper they line transmitting key information over public channels as a scenario which pose major risks to the privacy. As a solution they present the concept of public key cryptosystems where two distinct keys are used as well as one-way trap-door functions. For trap-door functions inverse exists, but it is difficult to compute, and calculations demand a certain trap-door information.

Many traditional signature schemes are trap-door functions by nature (Goldwasser, Micali, Rivest 1995).

Using two distinct keys, public and private, the privacy of the message is no longer so uncompromised. With the public key anyone can verify the authenticity of the signature as shown in figure 9. However, because of the private key only the sender possesses the information needed to form the inverse. This information is called the 'trap-door', hence the name of this scheme.

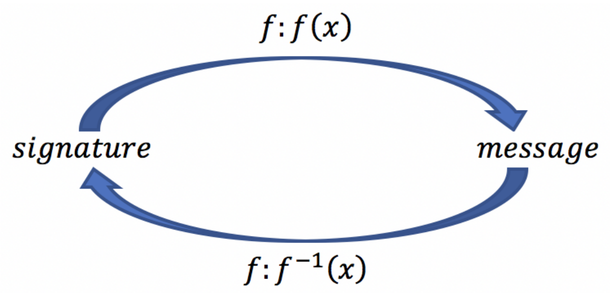

Figure 9. Trap-door scheme.

RSA algorithm

Rivest, Shamir and Adleman (1978) presented an algorithm which could be used to encrypt and decrypt message asymmetrically. This algorithm was named after their initials, RSA. RSA's strength is the difficulty of factoring large random numbers which are used to form keys. Key pair method allowed that anyone with the proper public key could read the decrypted message, and the delivery of keys was no longer necessary, thereby solving possible key distribution problems. Another advantage of RSA was that anyone with the corresponding public key could verify the signature decrypted using a private key.

Given the multiplicative nature of RSA algorithm using a key-only attack, it is selectively forgeable. In these key-only attacks the attacker only knows the signatory's public key. Development of quantum computers can be seen as a threat for RSA signatures. (Goldwasser et al. 1995; ImperialViolet 2013)

Rabin signatures

Rabin (1979) introduced a new and improved version of previously mentioned RSA scheme with public key exponent 2. Here, we focus on the traditional Rabin scheme and the improvement suggested by Goldwasser, Micali and Rivest. Other schemes are left unexamined for now. According to Rabin by using this Rabin algorithm, forgery is almost impossible considering the difficulty of unknown factorization. Simplicity of this method is one of the factors granting its efficiency, and therefore this method demands less computational capabilities. Similar to RSA algorithm, Rabin signatures use factorization where public key is calculated as a product of two large primes which are kept private.

Elia, Piva and Schipani (2011) proposed an improvement on the Rabin scheme trying to solve the problem around message decryption. The importance of choosing right root for the decryption is essential and one of the raised problems of Rabin signatures. This arises from the four-to-one mapping and can possibly have harmful effects to the changes in computational costs. They present a new padding mechanism as a solution. Pad (*U*) is used to overcome the signature generation problem. They suggest a padding mechanism where no attempts to derive *U* are necessary. Deciphering is possible if and only if under certain circumstances mentioned in the original paper.

Lamport signatures & Merkle signatures

In 1979 Leslie Lamport presented his idea about constructing digital signatures using a one-way function. It was an improvement compared to the Rabin signature method discussed above. With the one way function the encryption process is computationally easy, but computational abilities during that time were not efficient enough to come up with the inverse. In other words, for the given the encrypted message it is computationally infeasible to find the inverse of that function, and so it was impossible to solve the original data, and then the privacy is preserved. (Diffie & Hellman 1976; Lamport 1979)

Ralph Merkle published his concept in the late 1970s. Merkle signatures (also known as Merkle trees) function as an alternative to previously mentioned RSA algorithm and digital signature algorithm which both are vulnerable towards attacks by quantum computers. As presented above, they are a combination of hash-based cryptography and one-time algorithms. In a Merkle tree each non-leaf mode contains the hash of its children, so the hash tree itself is a binary tree. The root of the tree is the original public key. The tree form offers the possibility to locate the authentication path easily and check the authenticity of the signature. This offers a way to avoid the risk of forgery caused by the vulnerability of one-time scheme-based Lamport signatures. (Merkle 1979)

2.1.2 Biometric recognition

Biometric authentication functions based on identifying some characteristics of a user. Strength of usage of biometrics in identification is the uniqueness of each individual. This identification process can be performed for example from individuals’ eyes, hands, speech and facial bone structure. Each biometric trait used for user identification ought to be in an ideal case universal, unique, permanent and collectable. Though, in reality people’s willingness to give out sufficient biometric data for constructing reliable biometric system might not be high. Other aspects to consider as well is the system performance. What is the trade-off threshold between accuracy and speed? If our system has a high-accuracy identifying users but this process is extremely time consuming, the system is not ideal and efficient. (Jain et al. 2000)

Quite interestingly, the individuals' brain signals have also been studied to aid user identification and verification. The study by Saini et al. (2018) shows that each individual has a unique electroencephalography (EEG) signature. Similarly, Sreeja and Misbah Uddin (2017) examined the possibility to construct an online signature methodology using deoxyribonucleic acid (DNA) hashing. Further consideration of both of these studies and some related literature are left outside of this thesis.

Biometric recognition combines new innovations to authenticate the user. Novel facial recognition solutions have been presented to ease this identification process for the user. Avaintec introduced a solution for confirmation of identity which asks the user to say a specified number code to a mobile phone's camera and this way authenticate the transaction (Yrittäjät 2018).

There still exists some problems with facial recognition software. According to is one of the world's notable technology companies Microsoft (June 26, 2018) one of the reasons for false identifications for people with different colors, is the lack of sufficient data. This is why it is important to remember that any AI system is only as good as the data used to train them (Microsoft June 26, 2018).

While using iris recognition on mobile devices has posed some major difficulties to be faced. Especially, there have been problems with sensor interoperability. Galdi et al. (2016) proposed a multimodal approach to solve the obstacles concerning authentication based on user's iris recognition. The article emphasizes the fact that through combining biometric together with a user's physical trait, the level of authentications' security is higher. The highest security level can be reached with a biometric recognition solution which requires something the user has along with something the user knows and something the user is or does. The idea of e-signing by repeating a specified, unique code to a camera follows this principle. Constructed on the same basic principle, Hayashi et al. (2014) introduced a system which can identify users from their bodily structure and hand waving patterns.

2.2 Research of the benefits

The benefits gained from using the e-signatures can be divided into three categories. These categories are environmental, efficiency and user experience. I decided to concentrate on the last two advantages. The focus of benefit literature is presented below in figure 10. Although, the environmental aspect is crucial nowadays concerning the global warming, it's considered ancillary. Though, the environmental benefits of the usage of e-signatures are linked to the digital form which decreases the need for paper and transportation. With e-signatures we are able to cut down the costs created from printing paper, mailing documents and storage units for filing. Efficiency and user experience are closely linked to accounting and the scope of this study. Those two also are connected to one another.

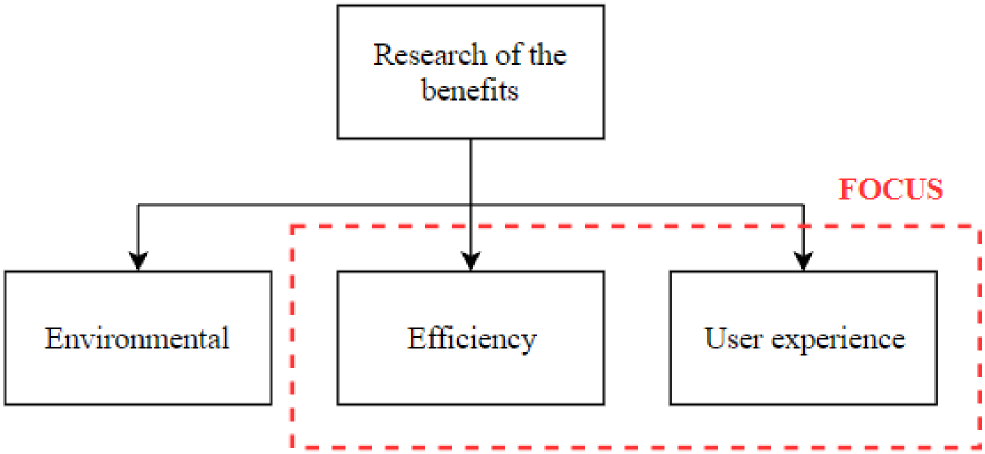

Figure 10. Focus of benefit research.

Also, on a very basic level the difference between costs from traditional handwritten signatures and e-signatures can be estimated. For example, with e-signatures the costs attached to shipping, warehousing and printing are eliminated or at least minimized. Furthermore, cost reductions are gained through labor costs. Employees do not have to use their working hours on printing, scanning, validating, posting and achieving documents. With electronic document databases, the time used to search a specific document is shortened, and the proportion of lost documents decreases. All in all, e-signatures allow the processes to speed up, and therefore create cost benefits. However, there are some downsides about e-signatures. This aspect of economic benefits is closely connected to efficiency.

Lazy user theory proposed by Collan and Tétard (2007) is introduced in this section. The theory in itself is extremely interesting because people tend to choose the easiest alternative which answers to their demand because they inherently are lazy.

Trust that both the message and signature are authentic is one of the key concepts of e-signatures. Without this trust the goals of e-commerce are left unachieved (Smedinghoff & Hill Bro 1999). This applies to other aspects of benefits of e-signatures. We need to obtain the trust for the overall digital process. The common awareness of the e-signatures' legal standpoints needs to be emphasized and the tools for detecting and preventing possible tampering of documents in electronical form ought to be enhanced.

2.2.1 Environment

Environmental benefits of the usage of e-signatures are quite obvious. By building a functional digital environment, the environmental benefits can be achieved along with the increase in efficiency. Without need to print the document for signing, we can save paper and thus forests. Also, the demand for ink shall decline. Especially the environmental effect of ink cartridges is unpleasant since the option to recycle those are limited. Ink is oil-based, and the environmental effects of oil production are questionable. Research around this is limited because of the huge industries behind the production.

This makes e-signatures sustainable choice environmentally. Furthermore, without need to store signed paper documents in achieves the space can be repurposed for something else to enhance business processes. Further evaluation of environmental consequences of signing documents by hand are disregarded. This thesis emphasizes the efficiency and the user usability of e-signatures.

2.2.2 Efficiency

Desire to ease come inherently from nature. Preferring lazy, efficient choices can be observed in natural and behavioural sciences. Like the second law of thermodynamics states that every attempt to reduce entropy in any system will discharge always greater entropy into its environment (Marinko 2012). In essence, entropy of an isolated system cannot never decrease. This supports the idea to prefer solutions which allow to user to be lazy. Similarly, in physics there is a theory declaring the superiority of selecting the path of least resistance. By allowing us to choose laziness, we are able to conserve energy and other resources for more meaningful tasks.

We need to remember that internal efficiency of an e-signature solution does not every time pass on to the end-user. Another remark to recall is that preferring electrical solutions is not always the most efficient choice. Here again the needs of the end-user have an effect to the decision of solution selection. Efficiency, for example cost efficiency, can too be achieved through a great user experience. Standardization of user interfaces in some level could be beneficial for obtaining this wanted experience. Since the efficiency is closely linked to the user experience and the Lazy User Model, the discussion is continued in the next sub-chapter.

2.2.3 User experience

2.2.3.1 Lazy User Model

Collan and Tétard (2007) presented the lazy user theory to explain how an individual chooses a solution from all the possible solutions available to fulfill its (his / her) needs. The solution is selected based on the amount of effort the solutions require from the user. The process of selecting the solution is referred to as a solution selection process. According to this theory the user is supposed to select the solution which demands the least effort. So, user is lazy. The theory can be implemented to the technology adoption. In our case, this means that a user would choose to use e-signatures if those would demand less effort in comparison to handwritten ones. In this way, this theory is as well linked to the adoption research.

The process begins from a user need which creates a place for a solution. The solution must be available for the user. Thus, all possible solutions form a solution set. Additionally, user state limits the solution set. This set cannot contain any solutions which are not accessible for the user. Then the solution selection is carried out from this solution set based on the overall effort, including both mental and physical effort, it demands. The user guesstimates the total amount of effort. (Collan & Tétard 2007)

In their paper in 2011 Collan and Tétard presented Lazy User Model (hereinafter LUM) based on the lazy user theory of solution selection. As stated above, the principle behind this model is the principle of least effort which is based on laws of physics. Furthermore, both the switching and learning costs of the user limit the set of possible alternatives. (Collan & Tétard 2011)

LUM is closely related to the adoption research of e-signatures as well as the benefit research. If a solution or technology violates the ideas LUM, the probabilities of its success are lower than with a solution allowing its users to be lazy. Basically, the idea is all about allowing the system to be optimized. Through optimization, the resources are consumed rationally and the high efficiency together with desirable user experience. In the focus of this thesis, LUM is related to the process of finding the optimal, least effort way of authorizing in administrative processes.

2.3 Adoption research

For a successful adoption of e-signatures as a company policy, there is some challenges to be confronted. Change resistance is one of the most common challenges experienced during adoption phase of new technologies. Typically, unknown is grasped as frightening where as familiar solutions feel safe. The first few months in the adoption process are the most critical ones for the future of the said technology. There might almost be a make-it-or-break-it situation in hand.

There have been developed some paradigms to model the acceptance of new products and services in a community (e.g. a company). In this sub-chapter, some of these technology adoption models are presented with some remarks about adoption of e-signatures. Furthermore, the importance of preserving data privacy is briefly discussed. The data nowadays is becoming increasingly high-volume, high-velocity and high-variety. These 3Vs form the widely recognized definition for Big Data (Laney, D. 2001). Big Data solutions can be considered as a one alternative when archiving huge volume of electronically signed documents efficiently.

Chang et al. (2007) investigated the adoption of e-signatures in hospital environment. They identified healthcare industry to benefit greatly of information technology (hereinafter IT) transformation, especially electronic records. The study emphasized the efficiency and possibility to decrease expenses through switching to e-signatures. Recognized factors for a successful adoption phase of e-signatures are adequate resources channelled to IT development and management, and the satisfactory co-operation and communication through the whole organization. In their analysis of data collected from selected Taiwanese regional hospitals, they found out that lack of sufficient information system (hereinafter IS) personnel delays the adoption of e-signatures. Another important identified factor affecting this adoption process is the prevalent government policy. These factors affecting a successful adoption of e-signatures is summoned to a figure 11 below.

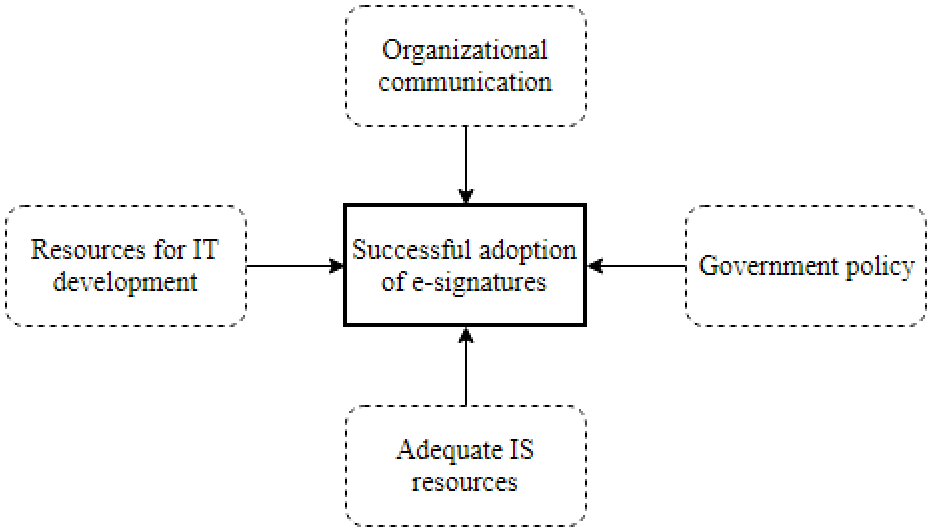

Figure 11. Factors affecting the e-signature adoption (after Chang et al. 2007).

Srivasta (2011) examined reasons why there occurs some resistance of change in the adoption process of e-signatures. Some of these reasons he identified in his study were congruent to the results from the study by Chang et al. (2007) discussed in the paragraph above. Because of the lack of proper knowledge about the e-signatures, some of the end-users might grasp the e-signing solutions complex or frightening. People also tend to emphasize the possible security concerns, for example improper or illicit use of signatures. Despite of the legislation stating the equivalence of e-signatures and handwritten ones, the legal concerns about the validity of e-signatures remains. Additionally, the total costs of e-signatures are envisioned to be larger than they actually are. Here, the education and training of end-users are seen as the greatest expense. Lastly, the cultural aspect of signing documents by hand is risen. The custom of habit stays relentlessly since “we have always done this by hand”. This phycological aspect must be taken into concern when managing the switching from handwritten signatures.

Shao et al. (2017) identified a system lifecycle for some electronic solution. First, after recognition of a need a managerial decision needs to be made to choose some solution to fulfill this demand. Next step is the adoption of the chosen technological solution which is followed by the implementation phase. During implementation the evaluation of costs and performance are made. Then, in assimilation phase the chosen solution is adapted to the company's needs and policies. For a successful adoption of the solution, it is crucial to truly understand the actual role of that system in the context of business operations. Final step before switching to a new solution, there is the extension phase.

Solution selection process could be used to explain why some technologies fail while others succeed. This process begins by gathering knowledge about the specific solution. Then it is followed by the first time use where the judgement of accepting or rejecting is done. Knowledge base is starting to form during the early use phase. Final step is the routine use. There the usage of needed operations is fluent and the capabilities of solving possible problems grows to sufficient level. (Collan and Tétard 2011) This offers insight to adoption processes of technological solutions. Laziness of the user leads to the fact that otherwise great product fails due to its difficulty of use. There we can state that the familiarity of the technical solution is one of the success factors.

2.3.1 Data privacy

With e-signatures, the confidential communication is accomplished when the planed receiver is the only one able to read the message (Férnandez-Manzano & González-Vasco 2018). One possible solution to guarantee this is through the use of proper encryption technologies, for example with digital signatures.

Today the use of Big Data is increasing, and the amount of data collected each moment is enormous and the its volume grows constantly. This creates great concern on the privacy of individuals (Férnandez-Manzano & González-Vasco 2018). Privilege management is a hot topic in this area. We need to find effective ways to handle sensitive data. For instance, biometrics uses extremely high-sensitive information to identify the users.

Assuring non-repudiation and validation of document integrity are issues arising from the use of e-signatures (Goswami et al. 2014). With the growing share of e-commerce, the possibility of data misuse and the integrity of authorities handling this data, especially CAs, must be considered (Bankhouse 2002).

One solution to this is the new GDPR (2016/679) policy proposed by EU which was presented earlier in chapter 1.4.2. However, its downfall is that a penalty for negligence of this regulation is fines. This basically means that you can get away with money from improper use of personal data and with tampering sensitive personal information. Over last decade, there have been concerning number of news about major companies committing this type of crimes and hence being guilty of negligent handling of their users' sensitive, personal data.

Under the topic of privacy management Danezis et al. (2015) identifies six main topics which companies ought to engage in. These goals are confidentiality, integrity, availability, unlinkability, transparency and intervenability. First three are about data security in general and last three about cryptography. All these goals can be achieved quite effortlessly but still they demand work. Poor data privacy policies might quite probably affect negatively to the company image (Férnandez-Manzano & González-Vasco 2018).

3 Empirical section

In a study conducted by Pohjoisranta Burson-Marsteller and Avaintec (2018) the general opinion about e-signing of Finnish citizens was investigated. The population in their study was 1,000 Finnish citizens between the ages of 18 to 70 years. As a result, they found out that generally people do not consider e-signatures as legally binding as handwritten ones. People also tend to see the e-signing less secure way of signing mainly because of possible risks of fraud and data security threats. However, the majority of the respondents see the e-signing more effortless option of these two. With e-signatures people value the most the simplicity and possibility to sign anywhere. This remark supports the ideas of Lazy user model. Although, this study is for marketing purposes instead of serving academic interest, we can observe the similar pattern and the linkage to Lazy user theory.

Like state of the art, this empirical section is also trifold. Preliminary plan for conducting this section of the thesis is presented in the appendix 1. This progress is illustrated below in figure 12. We begin with from normative process descriptions of a few e-signature platforms. Next, we continue by identifying different factors affecting the total cost of e-signature process. Then, we build a mathematical formula form these factors which can roughly tell us the total costs and compare those to the costs form usage of traditional, hand-written signatures. Finally, we combine all these sub-section by reflecting these ideas and remarks to the earlier presented lazy user model.

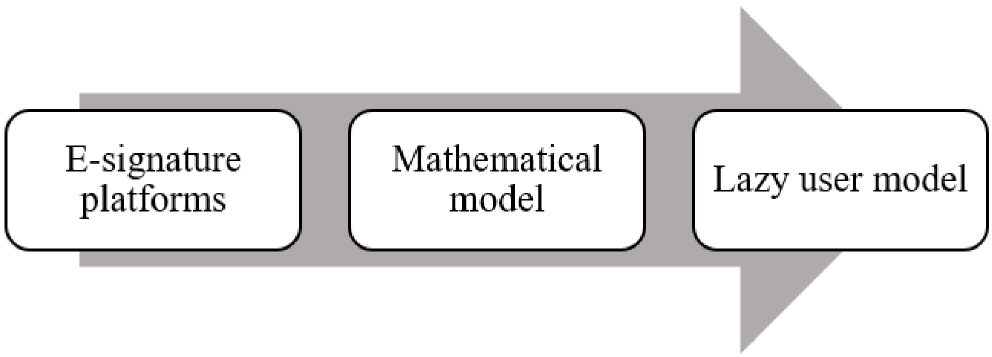

Figure 12. Empirical process.

3.1 E-signature platforms

Here, in this section I provide a short, normative description about the e-signature process in each selected platform. Also, I will time each of the e-signing processes for comparison with both each other and the traditional, handwritten option. Here the focus is on presenting alternative solutions not services by different companies. All these services are then compared to traditional way of signing by printing and scanning. For this, I chose SignHero by Avaintec, Visma Sign by Visma Solutions, DocuSign's and Sarake's e-signature solutions. SignHero is free. Visma Sign and DocuSign both provide free trial as well as Sarake Sign.

All these services which I tested followed the same pattern described below in figure 13. First, the documented to be signed electronically was added to the service platform as a PDF file. Then, the user gives the email addresses to whom the invitations to sign will be sent. Finally, the signee can sign the document identifying either by using online bank identifiers or the individual email link.

Figure 13. eSign process.

Possibility to send multiple eSign invitations for a single document allows multiple persons to sign the document simultaneously. There will no more be a need to wait for one person to sign before the next can write one's signature. So, the overall process will become faster. Also, for an e-signature platform to be functional the signee is not requested to have an account in the platform rather the email link is enough.

The actual empirical section was carried out by testing each of the previously mentioned online services with the same PDF document. I clocked the approximate time this process took starting from opening the service providers' webpage to having my file on my computer signed. This results so that this section only focuses on situations where the to be signed document (i.e. the PDF file) is already in your possession and you also are the signee. Any other signing situations will be disregarded now. However, some of the factors describing the costs from e-signatures along with the time consumed during the actual signing process are included to the model. As a benchmark, I used the traditional way of first printing out the document, then signing it by hand, scanning it back to PDF form and finally having it on the desired folder on my computer. The results are presented later in sub-chapter 3.1.5.

3.1.1 SignHero

Avaintec offers three different solutions for digital signatures in SignHero product group. These are SignHero.io, SignHero Tailored and SignHero Kit. SignHero.is is a free cloud-based service available on the Internet. SignHero Tailored is more tailored solution for customers' needs. It is available both as a cloud service and on-premise. Last option, SignHero Kit is the most unique solution of these three, and it is available only on-premise. Here, we focus only on the free version of SignHero.

To use free version of SignHero, user must first register to the site. After registration, the document to be signed are send to the site in pdf form. SignHero will notify the user when document is finished being eSigned and ready to be downloaded for future use.

For the purpose of this thesis I tested this service. I used the test file provided on the site. Later with the other e-sign platforms, I used this same test file. After downloading the document, I needed to fill in my name and email address, and also check a box asking for confirmation about signing. In this step, there was the possibility to add multiple persons to request the signature. By using SignHero, the user accepts the terms of use and privacy policy of the service. After sending the information, I received an email including an invitation to sign. Before finally signing the document, I had to verify my legal rights to the file being eSigned. Once everyone requested to sign have eSigned, the original requester receives the document with signatures and the date on which the eSigning took place. The requester also has access to the audit trail showing the information about the process.

3.1.2 Visma Sign

Like many other companies, Visma Solutions (2018a) also provides a solution for e-signatures, Visma Sign. Invitation to e-sign documents is sent through e-mail or text message. Then the recipients identify using their online bank identifiers and their unique password from the email. Visma Sign offers an e-archive containing all the documents signed electronically by the user thereby eliminating the need to download the document to personal computer or cloud. This e-signature service is charged based on the number of signed signatures (Visma Solutions 2018b).

Visma Sign has a feature where the user can build complete signature lists for specific signee groups. Also, when asking for the signatures, the sender can specify the order in which the signatures need to be done. According to Visma (puhelinkeskustelu) the dispatch of the reminders to sign will automatized in a near future.

Differing to SignHero, Visma Sign demands the user to have an account to the e-signing platform. In my opinion this suitable for professional needs since it uses strong identification. But for amateur use the SignHero is the preferable choice. Since this thesis focuses on cases where you sign the document that you already have in your possession, SignHero is granted higher points for category “Effort”.

When starting to use Visma Sign for the first time, the email, phone number, personal ID number (henkilötunnus) and password is asked for. Then the user needs to verify their identity using strong identification, such as online bank identifiers. The time consumed in the phase of making the user id is left out of the overall duration of the signing process.

First, I selected an option to create a new document. Then I named the document and imported it from my computer to e-signing service. Next, I chose the alternative to sign the document myself. Invitation to sign arrived by email containing a link and a personal password. Then I was able to examine the document, download it, send a message to the inviter (this case to me) and finally e-sign it after identification done with online bank identifiers and my personal ID number. After signing, I got an email about the finished process and the signed document attached.

3.1.3 DocuSign

DocuSign claims to be the industry leader in e-signatures. Unlike other selections for this section DocuSign is from the US. Like other e-signature solutions, DocuSign also provides ways to manage documents, for example send notifications and track the state of to be signed documents (DocuSign 2018).

DocuSign demands whole name, email, phone number, job title and one’s industry for registration. After verifying my account, I was asked to create a password and select the security question.

The e-signing process starts by uploading my document, selecting signees (in our case myself) and send the invitation by email. The actual e-signing happens through the personal link in the email which leads to the DocuSign page. The signee is then asked to fill up some fields and conclude by clicking finish. The option to draw the signature “by hand” is also available.

At first this e-signature solution seemed more complicated since it offers more alternatives to customize compared to the other services I tested. Another difference to other solutions is that when e-signing the document, there was no direct button to sign it. The signee had to drag to signature field to the document in order to sign it. If the person sending the invitation request had added the signature field to the document prior sending it, the signee is not required to do that. Still, DocuSign is easier solution, demanding less effort than handwritten ones in paper.

3.1.4 Sarake Sign

Sarake Oy (hereinafter Sarake, 2018a) is a Finnish company providing digital services for data management. They offer a web-based service, online forms to be added into webpages tailored solutions for customers' own management systems. With Sarake Sign the signing invitation could be sent as a link by email and or text message, or it could be integrated to a service. The signee is then identified (Sarake 2018b)

Like, with Visma Sign, Sarake Sign asked for creation of user id. This time the personal ID number was not required. At the first sign-in after verifying the account, the user is asked to provide a phone number to which the access code is then send. Finally, after log-in, the user can start the e-sign process.

First, I selected the option for asking for e-signatures. Then followed by importing the selected file to the server. After uploading the document, I was offered options for e-signing. Here the default settings were that every signee needs to accept the document prior to signing and these acceptations could happen in any non-specific order. Lastly, I added myself as a signee. To conclude, before sending the invitation, I chose that the e-signatures would be placed to a separate sheet. I also could have written a personalized message but remembering the focus of this thesis, that would have been unnecessary, so I left that one blank.

Since in this case I was signing my own document, I was able to e-sign it directly from the web page, but I also got an invitation to e-sign by email. The actual e-signing was quick and easy, unlike with Visma Sign I did not need any passwords. However, if someone else had send me that invitation, I would have received a code for log-in. Now, I just had to click to accept the request and the click again to e-sign. After these phases, I received another email containing a link to the e-signed document at the web page.

3.1.5 Summarizing results

The table 2 below summarizes the times each signing process took approximately. I also added a row to represent the overall effort I experienced during the signing process. Effort is given points from 1 to 5 (Likert scale), 1 being the easiest option to serve to purpose/focus defined earlier and 5 being the option demanding most effort. The whole scale for this variable describing the linguistic preference can be seen in the table 2 below. The points are given based on my personal experience and they are congruent to the ideas of the LUM. Therefore, it is important to keep in mind that the values for efficiency are subjective.

Table 2. Intensities of effort with linguistic terms.

Intensity of Effort	Linguistic term
1	low effort
2	moderate effort
3	medium effort
4	strong effort
5	extreme effort

The third row in the table 3 demonstrates the easiness of mobile signing. Furthermore, we give points for effort of accepting and sending e-signatures invitations on the go. Like for “Effort” the values given are based on the ideas LUM and the linguistic terms can be seen from table 2.

We value and focus the laziness of the solution and left the privacy and security issues out for now.

These times contain some measurement errors due to human interaction. As well, by repetition the times would become more statistically accurate. Repetition also allows us (the signee) come to be more familiarized with the service, which likewise affects by decreasing the overall duration of the whole process. Another fact to keep in mind is the typing speed of an individual and the Internet connection available. Therefore, I chose to report durations rounded to nearest minute.

DocuSign (2019) offers a mobile app for managing e-signatures. From the solutions I tested it is the only one with a proper mobile application. However, other solutions are quite straightforward to use through mobile browser as well. Using SignHero with a mobile device to manage e-signatures is simple and fluent. Visma Sign does not have their own mobile application. Nonetheless both sending e-sign invitations and e-signing itself can be easily done mobile. Sarake Sign also does not have a mobile app per se, but their site accessed through a browser is straightforward to use also with mobile device. Accepting e-sign invitation using handheld devices is also simple and user friendly via email link. To conclude, I still have some doubts about the verifying the signee's identity through an email link. But in this thesis, I will disregard this.

Let us consider a situation where you have a document saved to a cloud and then you want to e-sign it the easiest way possible. With your handheld device it takes only eight to nine steps (figure x) which takes only few minutes. In comparison, the figure x below demonstrates the steps needed for handwritten, paper signature. The lightnings illustrate the plausible technical failures of printer. The number of steps is similar, but the process takes a lot more effort and resources when signing by hand. With e-signatures the signee is not fixed to a certain location, which emphasizes the laziness of that solution.

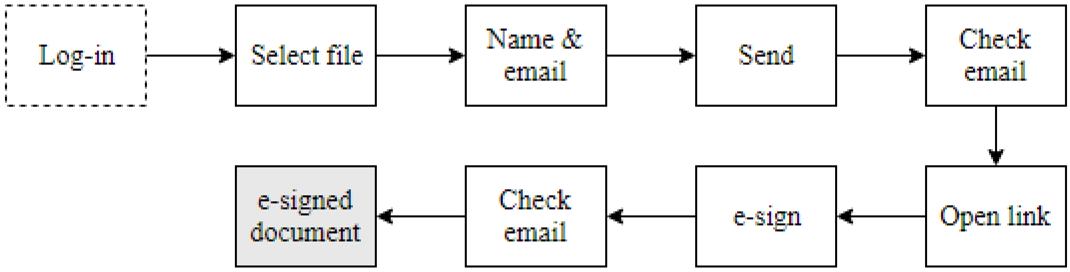

Figure 14. Mobile e-signature process.

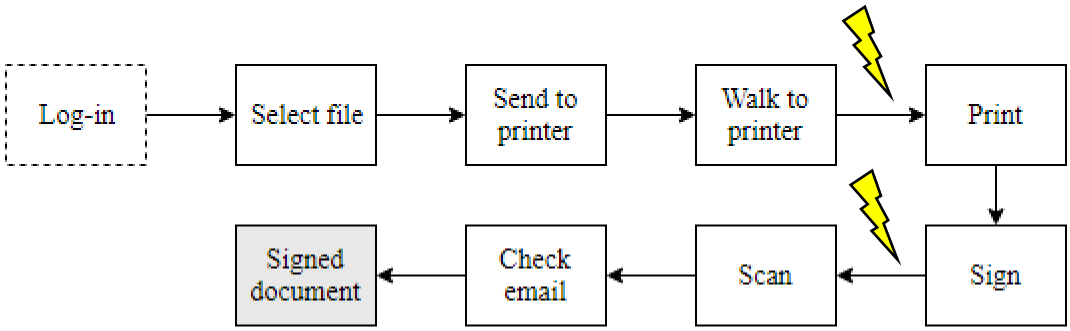

Figure 15. Traditional signing process.

Duration of the handwritten signature process is dependent on multiple factors. For example, the location of the printer, possible malfunction of the printer, shared printer with multiple colleagues, et cetera. Considering these facts, the handwritten signature is given benchmark time of five to ten minutes. Also, considering the effort, it is given points at the high end of the scale.

Table 3. *Summary of duration of signing processes.*

	SignHero	Visma Sign	DocuSign	Sarake Sign	traditional way benchmark
Duration	1 min	2 min	2 min	1 min	5 – 10 min
Effort	1	2	2	1	4 – 5
Mobile	1	2	1	1	5

3.2 Mathematical model

Here we present a mathematical model to aid decision-makers. Sometimes sole intuition is just not enough to come to a conclusion, so in essence our model offers decision support. Because, I did not get any real-life data to construct the model with, I decided to build only a rough framework for assessing the possible costs of switching to use of e-signatures over traditional, handwritten ones. It would have been interesting to run some analysis on data but adopting to changes in the environment is a key ability to have. Thus, I focus on gathering factors affecting the cost of this kind of decision to change. The model would ideally express the total costs through multiplicative coefficients for each of the factors.

In this section I wanted to point out the total cost through the signing process starting from acceptance of the document to be signed all the way to the archiving the document. Here, we can consider signing process to be a part of a document management system. Key resource comparing handwritten and e-signatures is time. Time is valuable, and if we are able to save time it leads to savings in other resources as well, thus creating economic value.

The actual modelling of the benefits of transitioning to e-signature-based processes is challenging because of the uniqueness of diverse businesses. I start by identifying the main factors affecting the total cost of signature process. These factors will function as coefficients in the final model. Then, I figure out how these factors impact changes with different signature volumes, and how they interact with each other. So, the goal here is to find a way to model this relationship as realistically as possible. One possible solution is to build a fuzzy model which could capture the uncertainty which characterizes life. But the nature of the relationship should become clearer after identification of the factors. It’s quite obvious that there will occur economies of scale up to a certain limit. Also, the relationship between the number of signatures during a certain period of time and the cost benefit gained from switching to e-signatures is sort of linear.

To remain within the focus of this thesis, we assume to have only two alternatives to sign. These alternatives are the traditional, handwritten way and the e-signatures. Motivation behind the decision to switch from handwritten signatures to e-signatures could be identified through LUM. Laziness and optimization of this administrative process is in our focus. We want to achieve easier, more effortless processes by making the decision to move to use e-signatures. If we start by assuming the superiority of the choice to use e-signatures instead of handwritten ones might lead to biased model.

Ideally, we would want to make an absolute type of evaluation. But under circumstances set by reality, relative type is more often the case. We could also build a decision support model to guide whether or not to invest to a e-signing platform or choose to use to use e-signatures rather than traditional, handwritten ones.

First, we need to identify factors affecting the total costs of switching to e-signatures. We cannot assume these different factors to be independent of one another. Because in real life there is almost always dependency to be observed. The question arises to how we can describe this dependency in the most accurate way. One way to handle uncertainty would be through fuzziness.

Another focal point here is the amount of benefit gain wished to obtain from the transition to e-signatures. As considering the benefit gain from usage of e-signatures instead of handwritten ones, the threshold for sufficient benefit can hardly be considered as a crisp threshold. The transition from insufficient benefit to sufficient one is gradual, without any crisp boundaries. If the benefit is measured in monetary units or laziness, it is impossible to assign a specific crisp value to describe sufficiency. Satisfaction increases starting from the unacceptability threshold all the way to acceptability threshold.

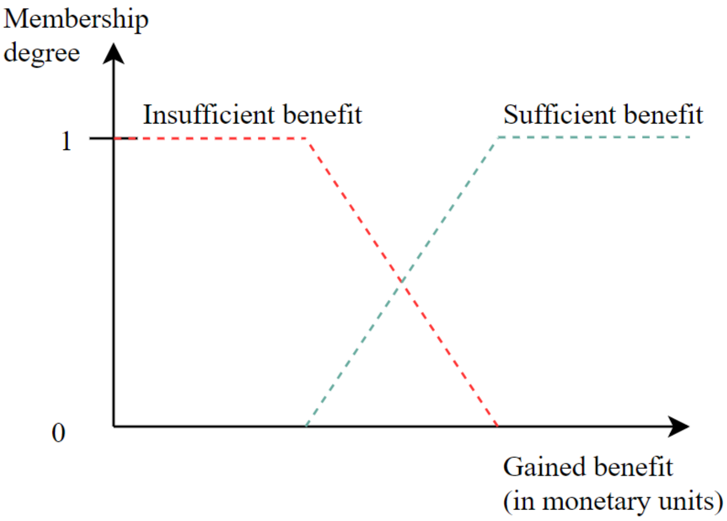

Figure 16. Fuzzy threshold for sufficient benefit gain.

Thus, in the figure 16 above the transition from insufficient benefit to sufficient is expressed as a fuzzy variable. The membership degree varies on a closed interval from zero to one [0,1] which can easily be transformed to percentages. The value tells us the percentage how much an observation belongs to a certain set (insufficient or sufficient benefit).

Here, we focus on presenting a model to showcase how the cost structure changes while altering signature volumes. In essence, our interest lies on the information about the total costs from switching from handwritten signatures to e-signatures. Truthfully, this is extremely difficult to measure using crisp values, meaning exact and precise values. If the decision is made to switch to e-signatures, what is the approximate vicinity obtained from this action.

The decision to switch is also affected by the intensity of preference to continue with the traditional way of signing. How much e-signatures are preferred to traditional way of signing, or the other way around? Is this preference measurable?

Model containing relative factors is prone to errors. To solve this, we need to have all the information. However, this is hardly ever the case. This takes us back to decision-making under uncertainty and risk. Further evaluation of the type of decision making is disregarded now. For the purpose of this thesis it is enough to state that more information available for the decision-making process the better.

With every model there arises trust issues. When can we trust the model? How do we come to the conclusion to finally trust? The final model should be so simple that the probability of misusing the model is minimized. Thus, the different factors should be explained explicitly, and the model should not use any extreme calculus. Moreover, this an accounting study focusing on the laziness of e-signatures without real-life data from which the analytical model could have been formulated.

$$cost\ of\ switching\ to\ e - signatures = (board\ meeting\ +\ administrative\ costs\ +\ learning\ costs\ +\ document\ management\ system\ +\ number\ of\ signatures\ *\ price\ per\ signature\ )\ *\ industry\ specific\ coefficient\ (+\ cost\ of\ e - signature\ solution) \qquad (1)$$

The formula 1 above presents the rough, directional model for estimating the cost with respect to the usage of e-signatures. The end of this chapter will then explain in a few words reasons for each of the factors in that model. To begin with, administration dictates that the switching decision ought to be enforced at least in a board meeting. This starts piling up the costs. Preliminary preparations before the meeting and the actions undertaken after that create more costs and demand resources. After the decision to switch to e-signatures, the learning costs arise. There will be costs concerning the training of employees, education ICT staff and development of IT systems.

The archive is the next thing to consider. Legislation dictates us to preserve certain document for a specified period time. If our signed documents are in paper form, they demand a reserved storage space and the possibility of losing some records increases as the number of documents increases. Additionally, time consumed to find a certain file from physical archive could add up to enormous amount. In some cases, the actual storage unit could be in a separate location. Without a proper document management system, the information about the current location of some record could in worst case be missing. Transforming an old paper archive to an electronic one, demands all the old documents to be scanned to a new e-archive. This process requires labor and time.

Then, when considering e-signatures and archiving of e-signed documents. Active search and mailing documents already stored electronically in some document management system. Overall, document handling is more efficient and faster with e-archive. In addition to laziness, the higher speed of both the signing process and the archive management support the e-signatures as a more suitable option.

Costs created from the signing process itself. This was already briefly discussed in chapter 3.1. When the number of documents to be signed increases, the total costs of the signing process increase. When switching this process to digital, the economic of scale could be achieved. This means that the total savings in monetary units and resources increases relatively when the number of signatures grows. Cost of digital signature service ought to be taken into account as well. However, this total price is dependent on the requirements of the user. So, here this is only discussed briefly.

Some industries benefit more from the usage of e-signatures than others. This supports the idea of adding an industry specific coefficient to the model. However, this is disregarded since our focus is on investigating adoption and efficiency of e-signatures on a general level. For future references, this might turn out to be interesting addition to the model.

3.3 Linkage to Lazy User Model

Finally, I shall revise the thoughts arose from the two previous sections and form a linkage to the ideas of the Lazy user model. The design of this model is presented earlier under chapter 2.2.3.1. in the State of the art section. I compare the thoughts from the e-signature processes and my own model to the Lazy user model. I wish to find something which would explain the possible gained advantages with the usage of e-signatures. I will also recommend ways to enhance my model with the ideas from the Lazy user model. In addition, I will identify features to include to an e-signature platform for it to become as good as possible based on the ideas of LUM.

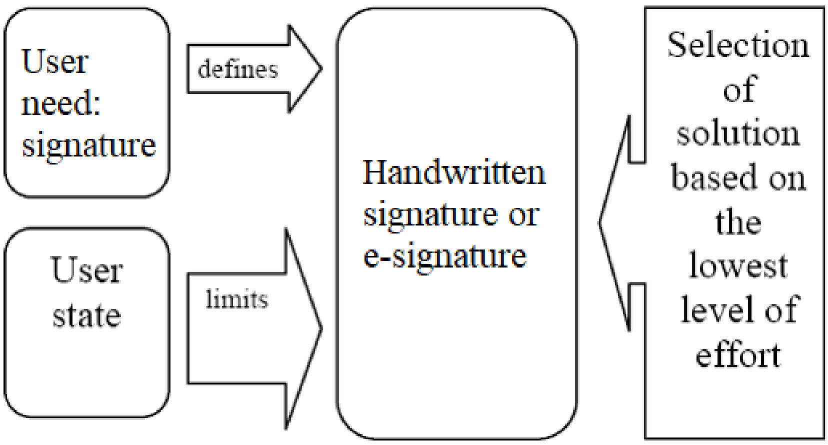

Figure 17. LUM and e-signatures (after Collan and Tétard 2011).

To implement the concept of LUM to suit our case, we need to assume that the effort can actually be measured in monetary units. The figure 17 above shows the modified LUM principle by Collan and Tétard (2011) to apply to the case of this thesis. Now the defining user need is to sign some document. The limiting user state varies depending on the situation of the user. For example, user might not have a printer available or the user might be in a hurry or in a different country than the other signee. Then, the set of all possible alternatives is limited to two to stay in the focus of this study. These options are traditional handwritten signature and e-signature. According to LUM, user is now supposed to choose the alternative based on the lowest level of effort. In most cases this is the e-signature.

Switching costs should be considered as an investment to possibly achieving competitive advantage in the market for a company (Hess & Ricart 2003). This assumes that through switching, the company gains significant benefit. We should consider switching to e-signatures as a long-term investment. Our satisfaction will increase after the learning phase. In the long-run, the selection of lazy solution benefits the user and will create economic benefit.

All in all, selecting e-signatures over handwritten ones seems to be supported by LUM. When considering the overall process from document without a signature to archiving signed documents going electronic nowadays is the way of least effort.

4 Conclusions

4.1 Summary of the study and research questions

In essence, this thesis is about optimizing a crucial part of an administrative process which is authorizing by signing. To remind us, the research questions are revisited below.

What is the legislation surrounding e-signatures?

What is the state of the art of research with regard to e-signatures?

What are the total costs and benefits of e-signatures in comparison to hand-written ones?

How the adoption of e-signatures should be implemented in the context of the Lazy User Model?

Is usage of electronic signatures beneficial?

The first two sub-research questions were answered in the chapters 1.4 Legislation and 2 Literature review – state of the art of e-signature studies. The focus was in the examination of US, EU and Finnish legislation. In the state of the art section I focused on the technical literature, research of the benefits and adoption research. Technical research presented was about e-signatures which was then divided into studies about digital signatures and biometric recognition. Benefits of the e-signatures are environmental, efficiency and user experience. The Lazy User Model was presented in this section. Finally, I presented some studies concerning the adoption of e-signatures and raised some concerns about the data privacy.

Next two sub-research questions were answered in the chapter 3 Empirical section. When considering the signing process as a whole, the e-signatures turned out to support the LUM framework better. Through the adoption of e-signatures, users are allowed to be lazy and therefore focus on their main tasks. Whereas the handwritten signatures are more prone to exogenous disruption, and as a technology signed documents are becoming outdated. The costs from e-signature adoption even out during its working life. At the beginning there occurs some costs concerning the implementation. These costs can be through as an investment rather than sunken expenses. For e-signature solution to be successful, it should be straightforward to use and be able to adapt to the users' needs.

To conclude, the LUM supports the adoption and usage of e-signatures in comparison to traditional, handwritten ones.

4.2 Reliability and validity

As I mentioned earlier the lack of sufficient real-life data poses some major reliability questions on the validity of the rough model presented in chapter 3.2. However, the notions about e-signature adoption and use in the context of the LUM the results still are worth to consider. Still, the state of the art literature review should be easily repeatable with the help of the process description I provided in the beginning of the chapter 2.

4.2.1 Further studies

Further studies around this topic are vast. Basically, the investigation of Lazy User Model framework together with e-signatures is extremely interesting. First of all, I would suggest a study around this topic with a clear focus to some industry and real-life data. With the analysis of that data, the evaluation of a more accurate model for estimating the cost structure of switching to e-signatures could be done more realistically. This way we could be more able to investigate the generalizations of cost estimation related to e-signature adoption and construct a functional decision support model. Fuzzy decision theory could also be explored to give insights about the costs and benefits of e-signatures.

Some other alternatives for future studies could be the examination of e-signatures in different economies. For example, possibilities and infrastructural readiness of developing economies to adopt e-signatures in their processes. Also, how would the usage of e-signature solutions could be altered to tackle with possible crisis or situations where the Internet connection would not be available to use.

On the technical approach we could examine the effects of different encryption technologies on the adoption and use of e-signatures? One interesting viewpoint to this is to consider how can the technology used in the documents be so general that we can still read the documents after certain number of years. For example, the file format used 20 years ago has changed dramatically to what it is today. Maybe one solution is to harmonize the practices and technologies.

As the amount of user data collected and the value of that increase, the further investigation of possible threats with e-signatures and personal data become current. We also ought to examine the politics behind decision-making. Who are the people behind decisions and who actually profits from those decisions? What do the decision makers actually value? What else than solely profit is appreciated by the decision makers? How can we achieve efficient satisfaction in the long run? How should management in change be implemented to reach a successful adoption of e-signatures?

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Appendices

Appendix 1. Preliminary plan for conducting the empirical part

As mentioned in the actual thesis, the empirical section is divided into three sub-sections:

- E-signature platforms / solutions
- Mathematical model
- Linkage to Lazy user model

E-signature platforms

I'll probably begin from the section which presents 3-4 different e-signature platforms. I chose these platforms based on possibility to try those free of charge. In this point, my initial selection includes Avaintec's SignHero, Visma Solutions' VismaSign, DocuSign, and Sarake's Sarake Sign. I've already tested SignHero successfully and wrote a normative description of the signing process. In addition, I will roughly measure the time each of these e-signature solutions takes and compare those times both with each other and to an approximate estimate of signature process with handwritten signatures both with scanned and mailed documents.

Mathematical model

Next section introduces a mathematical model to predict cost estimate of e-signatures and traditional, handwritten signatures with different volumes of signatures. Basically, this model tries to guestimate the final cost of signature process by adjusting necessary resources. For example, if we have a factory producing groceries and we're interested in the total cost created by usage of traditional signatures in comparison of e-signatures. We want to know if the transition to e-signatures is reasonable.

In this section I want to point out the total cost through the signing process starting from acceptance of the document to be signed all the way to the archiving the document. Here, we can consider signing process to be a part of a document management system. Key resource comparing handwritten and e-signatures is time. Time is valuable, and if we are able to save time it leads to savings in other resources as well, thus creating economic value.

The actual modelling of the benefits of transitioning to e-signature-based processes is challenging because of the uniqueness of diverse businesses. I start by identifying the main factors affecting the total cost of signature process. These factors will function as coefficients in the final model. Then, I figure out how these factors impact changes with different signature volumes, and how they interact with each other. So, the goal here is to find a way to model this relationship as realistically as possible. One possible solution is to build a fuzzy model which could capture the uncertainty which characterizes life. But the nature of the relationship should become clearer after identification of the factors. It's quite obvious that there will occur economies of scale up to a certain limit. Also, the relationship between the number of signatures during a certain period of time and the cost benefit gained from switching to e-signatures is sort of linear.

Linkage to Lazy user model

Finally, I shall revise the thoughts arose from the two previous sections and form a linkage to the ideas of the Lazy user model. The design of this model is presented earlier under chapter 2.2.3.1. in the State of art section. I compare the thoughts from the e-signature processes and my model to the Lazy user model. I wish to find something which would explain the possible gains advantages with the usage of e-signatures. I also will recommend ways to enhance my model with the ideas from the Lazy user model.