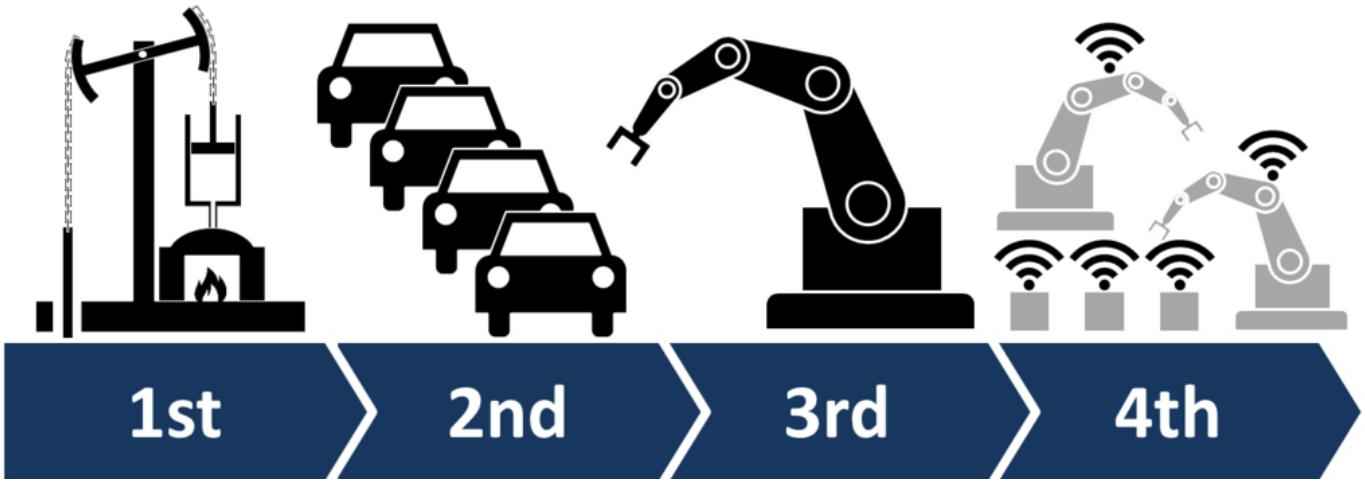
# Industry 4.0: 2nd generation software solutions




# SaaS adoption in the manufacturing industry

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Management summary

In this paper we will examine the adoption process of the cloud based solution of Software as a Service (SaaS) in the manufacturing industry by Small and Medium Enterprises (SMEs). The purpose of this research is to define which factors influence the adoption process of SaaS, the reason for this is that many large software vendor such as Afas, have announced that they will only provide there software in the near future as a cloud based solution with a subscription business model. While switching to a new on-premises software provider, requires a huge upfront investment, it will be interesting for SMEs to switch to a SaaS solution. Nevertheless, cloud adoption by SMEs in the manufacturing industry is still lacking behind. This paper will use the Diffusion of Technology (DOI) theory in combination with the Technology, Organization, Environment framework (TOE) to determine which factors influence the innovation adoption process in the manufacturing industry. Furthermore, it will provide a Risk and Opportunities assessment of SaaS solutions and it will examine if there is a correlation between SaaS adoption and an increase in value of SMEs. Finally, this paper will compare the adoption process of SaaS to the adoption process of the Enterprise Resource Planning (ERP) systems, to see if they follow the same adoption trajectory.

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# Chapter 1: Introduction

## 1.1 Problem Indication

Information technology (IT) has long be evolved from his traditionally orientation of administrative support in the business environment to a more strategic role within an organization (Henderson & Venkatraman, 1993). This new industrial revolution where Information Systems (IS) such as Enterprise Resource Planning (ERP) and the Internet of Things (IOT) changing the paradigm of the IT landscape. The rise of cloud computing is the next step in the IT evolution that has the potential to transform a large part of the IT industry while it shifts the way we use IT (Armbrust, Fox, Griffith, Joseph, Katz, Konwinski, & Zaharia, 2010) Cloud computing is part of the new beliefs that sees computing as a utility (Buyya, Yeo, Venugopal, Broberg, & Brandic, 2009).

Computing as utility means that users are able to access services based on their needs and their requirements, like we already have with gas, water, electricity and telephony (Buyya, et al., 2009). Computing as utilization has the potential to transform a large part of the (IT) industry, and is therefore is part of the fourth industrial revolution, also called: Industry 4.0 (Lasi, Fettke, Kemper, Feld & Hoffmann, 2014). Cloud computing can make software for Small and Medium enterprise even more attractive by changing the way it is delivered, as a service instead of as a product, changing the way software is designed and purchased. With Software as a Service businesses do not longer require huge upfront investments to purchase the software or capital expenditure to maintain it (Armbrust et al., 2010).

Cloud computing (Cloud) is an on-demand self-service where a user can use remote servers to process, store and manage data, rather than have the data on a physical server on the premises or personal computer. The Cloud is often a pay for use system where the user only pays for the amount of servers or applications that is uses, it can easily be adjusted for the current needs of the user. The Cloud can be divided into three different kind of service models: Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS) (Mell & Grance 2011). This paper will be focused on the service model: Software as a Service (SaaS). With the SaaS service model, consumers can access the providers' application through a thin client, such as a web browser, without the underlying software being physically on the device or even on premises

(Mell & Grance, 2011). The first model of service based software was called Application Service Provider (ASP), bus as it did not have a sustainable business model it never really had a breakthrough (Ju, 2010). After the failure of ASP, saleforce.com introduced a new form of Software as a Service, with a sustainable business model were customers use the software on a subscription basis (Cusumano, 2010) The consumer pays (often per time period) for the amount of licenses or the specific services he or she requires (Armbrust et al., 2010).

Cloud computing is slowly creeping into the business strategy formulation and implementation of Small and Medium Enterprises (SMEs) (Gupta, Seetharaman & Raj, 2013) for the reason that it can bring a competitive advantage for its major goal is to significantly reduce the cost of IT services while increasing processing throughput, reliability, availability, flexibility and decreasing processing time (Alshamaila, Papagiannidis & Li, 2013; Hayes, 2008; Low, Chen & Wu, 2011) While cloud computing has the potential to provide advantages on both strategic and operational ways, the adoption rate by SMEs is not growing as fast as expected ( Buyya et al.,2009; Goscinski & Brock, 2010; Low, Chen & Wu, 2011). A reason for this could be the perceived level of risk and cost (Alshamaila, Papagiannidis, & Li, 2013), while Cloud computing is still a disruptive technology that has not yet reached a level of maturity in the adoption process (Oliveira, Thomas, & Espadanal, 2014). This paper will research the willingness of SMEs to adopt cloud solutions further on basis of a combination of the Technology, Organization, Environment (TOE) framework by Tornatzky and Fleischer (1990) and the Diffusion of Innovation (DOI) theory by Rogers (1995).

The Economist Intelligence Unit has published a report about the adoption of cloud computing in the five major industries; Banking, Retail, Education, Healthcare and the Manufacturing industry. The report states that besides healthcare and education the manufacturing industry has the lowest adoption rate of cloud computing, only 42% of the respondents in the industry says there is a significant presence of cloud adoption (The Economist Intelligence Unit). While Healthcare and Education are prone to slower adoption due to government regulation, and are in a less competitive environment (The Economist Intelligence Unit, 2016), this paper will focus on SMEs in the manufacturing industry.

## 1.2 Problem statement

What factors influence the adoption of Cloud computing in the area of Software as a Service by small- and medium- enterprises in the manufacturing industry?

## 1.3 Research Questions

- What is Cloud Computing? **Chapter: 2**
- What are the Risk and Opportunities of Software as a Service? **Chapter: 3**
- What factors influence technology adoption in the manufacturing industry? **Chapter: 4**
- Does SaaS adoption increase the monetary value of a SME? **Chapter: 5**
- Does SaaS adoption follow the same trajectory as ERP adoption in the Manufacturing industry? **Chapter: 5**

## 1.4 Conceptual model

The conceptual model of this research as is shown in figure 1. Briefly describes the level of SaaS adoption depends on the combination of the Diffusion of Technology (DOI) theory (Rogers, 1995) and the Technology, Organization, Environment (TOE) framework (Tornatzky and Fleischer, 1990). Furthermore, the conceptual model includes top managements perception on risk versus opportunities, this perception can be influenced by the change in value of SaaS adopters in the same industry.

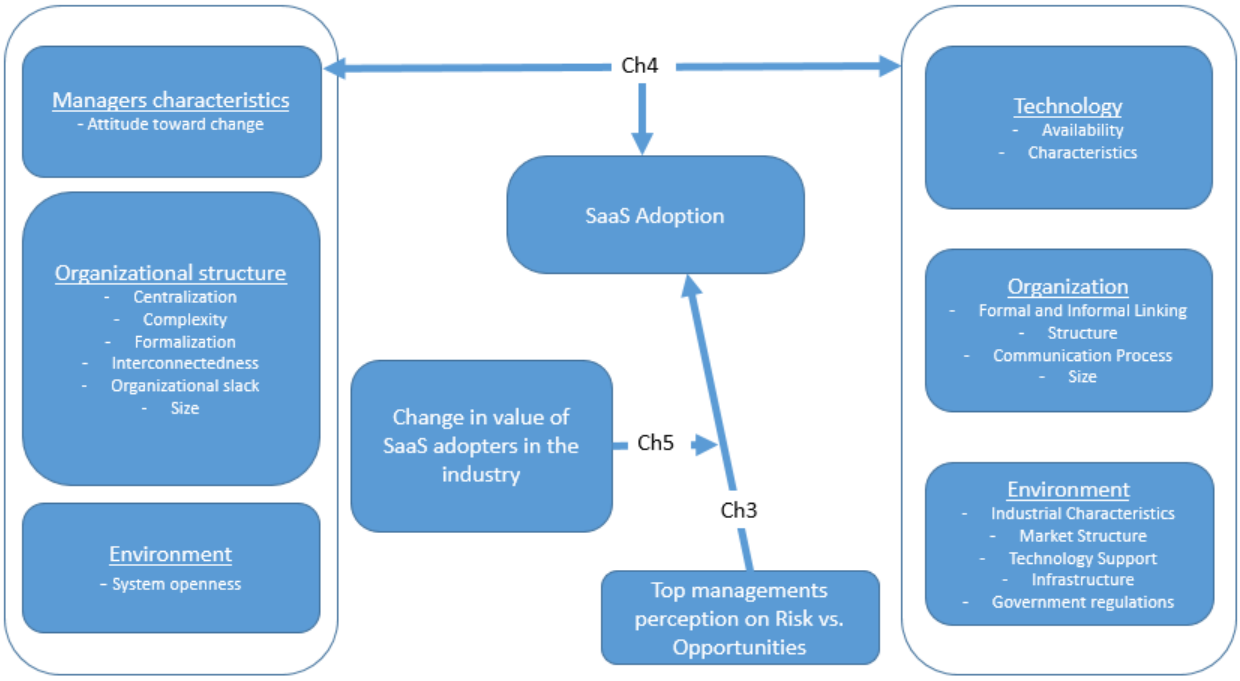


*Figure 1: Conceptual model*

## 1.5 Hypothesis

Three hypotheses belong to the conceptual model as shown in figure 1. In Chapter 3 we discuss the perceived Risk and Opportunities belonging to SaaS adoption.

- H0: Top managements perception on risk versus opportunities has a negative or no influence on the adoption process of SaaS.
- H1: Top managements perception on risk versus opportunities has a positive influence on the adoption process of SaaS.

Meaning that if top management perceive more opportunities than risk is has a positive effect on the SaaS adoption process.

Chapter 4 discusses the theoretical framework where we suggest that to determine the factors that influence the SaaS adoption we must combine the Diffusion of Technology theory (Rogers, 1995) with the Technology, Organization, Environment (TOE) framework (Tornatzky & Fleischer, 1990).

- H0: The factors as constructed by the DOI theory and the TEO framework, have no influence on the adoption of SaaS.
- H1: The factors as constructed by the DOI theory and the TEO framework, do have influence on the adoption of SaaS.

In Chapter 5 we have designed an experiment that examine the correlation between SaaS adopters and a change in value. We believe that if there is a correlation between value and SaaS adoption it amplifies the top management perception on opportunities.

- H0: A correlation between an increase in value and the adoption of SaaS has no or a negative effect on the top management perception on opportunities.
- H1: A correlation between an increase in value and the adoption of SaaS has a positive effect on the top management perception on opportunities.

## 1.6 Relevance

### 1.6.1 Academic relevance

The concept of Software as a Service is already been introduced 18 years ago by salesforce.com (Cusumano, 2010).In the meantime many studies about SaaS and Cloud computing have been done, see the categorization for an overview of papers used in this research on SaaS. But the main factor why this study is academically relevant, is that there are no studies that look at SaaS adoption by SMEs in the manufacturing industry without specifying a country. This study thrives to find the reason why the starters of the first industrial revolution, the manufacturing industry, lack

behind in the 4th industrial revolution, the smart revolution. Furthermore, this paper will show if the adoption process of SaaS solutions follow the same trajectory as the adoption of ERP systems, a solution that is now well adopted by SMEs worldwide (Buonanno, Faverio, Pigni, Ravarini, Sciuto, & Tagliavini, 2005). This is relevant from an academic perspective because we are just entering a new era of IT development, the industry 4.0 with new concepts such as the Internet of Things, Cloud computing and ERP. If this study shows that ERP and Cloud follows the same adoption trajectory, it helps future studies to define the overall adoption process of IT innovations.

### 1.6.2 Managerial relevance:

The Managerial relevance of this study is more evident, Cloud solutions are taking over the industry. Many large software vendors, such as Afas, are transitioning to a cloud only model, where they do not provide a traditional on premises software but only the cloud based solution whereby their customers must take a subscription to their software (Olsthoorn & Verbeek, 2018) The vice president of Gartner, a worldwide research and consultancy firm in the information technology sector (Gartner.com), even stated in a conference in 2017 that by 2019 at least a third of the largest software developers will only provide SaaS solutions instead of the traditional licensing software, (Sverdlik, 2017). Many SMEs that use one of those solutions must make a choice between adopting a cloud solution, or make a huge investment and switch to a different on premises software provider.

# Chapter 2: The Domain

This chapter will define the domain of this paper, it will provide the definitions and terminology this paper uses, and it will provide background information on the key subjects. First of all we will define what Small and Medium Enterprises are. Secondly it discusses the new concept of Industry 4.0 and gives an explanation about the ERP system that will be used during this paper to compare its adoption process to the adoption process of SaaS solution. Finally this chapter will define The Cloud, its definition, the service models and the deployment models.

## 2.1 SMEs

The criteria to be called a SME differs from country to country, for instance some countries use total assets, while other countries use the criteria of investment (Ayyagari, Demirgüç-Kunt, & Beck, 2003). Even within one criteria, such as number of employees, countries differ from criteria. Where some countries define a SME as an enterprise with a maximum of 250 employees will other countries define it as a company with 500 employees (Kushnir, Mirmulstein & Ramalho 2010). Therefore this paper will use the criteria that the World Bank / IFC has given about SMEs, these criteria are given in table 1 **(**Kushnir, et al., 2010; Ayyagari et al., 2003).

| | Number of Employees | Total Assets | Annual sales of up to: |
|---|---|---|---|
| Small Enterprises | 10 - 49 | $100,000 - $3,000,000 | $100,000 - $3,000,000 |
| Medium Enterprises | 50-249 | $3,000,000 - $15,000,000 | $3,000,000 - $15,000,000 |

*Table 1: Criteria for SMEs by the World Bank*

## 2.2 Industry 4.0

The manufacturing industry is characterized by the huge technological leaps the industry makes once every so often, these leaps changes the industry completely, and are known as industrial revolutions **(**Lasi, et al., 2014). The breakthrough that led to the first revolution was in the field of mechanization, after that came the second industrial revolution because of the assembly line and the intensive use of electricity the ability of mass production was now available in the

manufacturing industry. The third industrial revolution was the digitization of the industry. But now the 4th industrial revolution is going on, Industry 4.0, the smart revolution, where smart solutions such as Internet of Things (IOT), Cyber Physical Systems (CPS), Enterprise Resource Planning (ERP), Radio Frequency Identification (RFI) and Cloud computing are able to shift the manufacturing paradigm again (Lu, 2017). Industry 4.0, is still a visionary term, but it is also a realistic concept.

### 2.2.1 Enterprise Resource Planning

Enterprise Resource Planning (ERP) systems have changed the business environment in the 90s, and was one of the largest IT investments early 21st century (Hwa Chung, & Snyder 2000). It is appraised as one of the most important business innovations and its implementation could benefit businesses of all sizes (Seethamraju, 2015). The ERP systems can be defined as a single system that integrates all the core processes needed to run a company, such as Supply Chain Services, finance, procurement, HR, and others ("What is ERP | Enterprise Resource Planning Definition | SAP"). The ERP system was a solution for the industries growing need to integrate multiple processes across the company even better than its predecessors Material Requirements Planning (MRP I) and the Manufacturing Resources Planning (MRP II) could (Jacobs, 2007). The reason for this was that MRP I and MRP II where focused on the resources of the company, such as material, human capital and machinery. This mend that there were still many systems that did not integrate with the whole, and therefore it was not possible to see real time transactions (Jacobs, 2007). With the new ERP systems is was possible to see real time transactions between multiple divisions across the company (Klaus, Rosemann & Gable, 2000).

### 2.2.2 The Cloud

The Cloud has become a popular buzzwords surrounding the current IT developments (Wang, Von Laszewski, Younge, He, Kunze, Tao & Fu, 2010). Cloud computing, emerges around the world as the new IT solution in organizations (Nuseibeh, 2011). But there is still a lot of confusion surrounding the Cloud what is it precisely, what does it do and where is it good for (Fox, et al., 2009). The reason for this confusion is partly because there was no one clear definition. The paper of Vaquero, Rodero-Merino, Caceres and Lindner (2008), studied 20 definitions of the Cloud and came with one definition, namely: *"Clouds are a large pool of easily usable and accessible virtualized resources (such as hardware, development platforms and/or services). These resources can be dynamically reconfigured to adjust to a variable load (scale), allowing also for an optimum*

*resource utilization. This pool of resources is typically exploited by a pay per-use model in which guarantees are offered by the Infrastructure Provider by means of customized SLAs."* The paper however argues that the concept of the Cloud "obviously" still is changing, and that this definition is only how the Cloud is seen at the moment of publishing. (Vaquero, et al., 2009).

The National Institute of Standards and Technology (NIST) therefore has updated the definition of the Cloud and characterized five fundamental aspect of the Cloud. The NIST definition of the cloud is: "*Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."* (Mell & Grance, 2011). This means that a user uses remote servers, applications, networks, storage and/or services hosted on an external location instead of on the consumers own personal device. The Cloud consist of five fundamental aspects, three service models and four deployment models. (Mell & Grance, 2011)

The NIST has characterized five fundamental aspects of the cloud, these are defined is figure 2

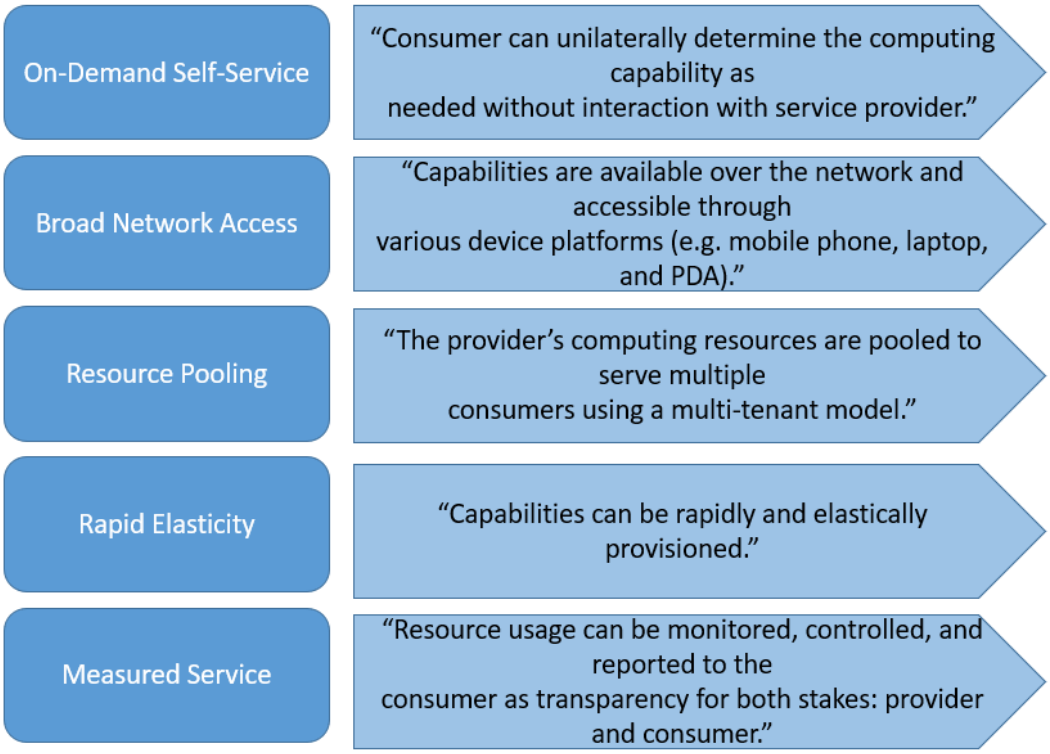


*Figure 2: Five fundamental aspects of the cloud. (Mell & Grance, 2011)*

#### *2.2.2.1 Service Models*

According to the NIST the Cloud consist of three different service models, these models can be seen as different levels in the Cloud. On each new level you will manage less by yourself and more of the services are managed by the vendor, see figure 3 (Pandey & Kavita, 2014).

The first service model is *Infrastructure as a Service (IaaS).* The NIST defines IaaS as "*The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, and deployed applications; and possibly limited control of select networking components (e.g., host firewalls).*" (Mell & Grance 2011). This means that the provider does hardly any management besides keeping the data center operational, but it is responsible for the housing, running and maintaining the hardware. Secure Storage Service (S3) and Amazon Web Services Elastic Compute Cloud (EC2) are examples of the IaaS service model (Bhardwaj, Jain & Jain, 2010).

The second service model is a *Platform as a Service (PaaS).* The NIST has defined PaaS as: "*The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment*" (Mell & Grance, 2011). This means that the provider of the service manages all the hardware as he does at IaaS, but besides that he manages also parts of the application software, such as security and your databases as a platform where the consumer can built his own applications on. Examples of PaaS are Google App Engine and Engine (Bhardwaj, Jain & Jain, 2010).

The third service model is *Software as a Service (SaaS).* The NIST also has defined SaaS: "*The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control*

*the underlying cloud infrastructure but has control over operating systems, storage, and deployed applications; and possibly limited control of select networking components (e.g., host firewalls)*" (Mell & Grance, 2011). In this service model the provider manages and owns all the hard- and software, and the consumer just uses the application, see figure 3. Some examples of SaaS are Oracle CRM on Demand and Salesforce.com (Bhardwaj, Jain & Jain, 2010).While SaaS is the main focus in this article, we will explore it even further later on in this chapter.

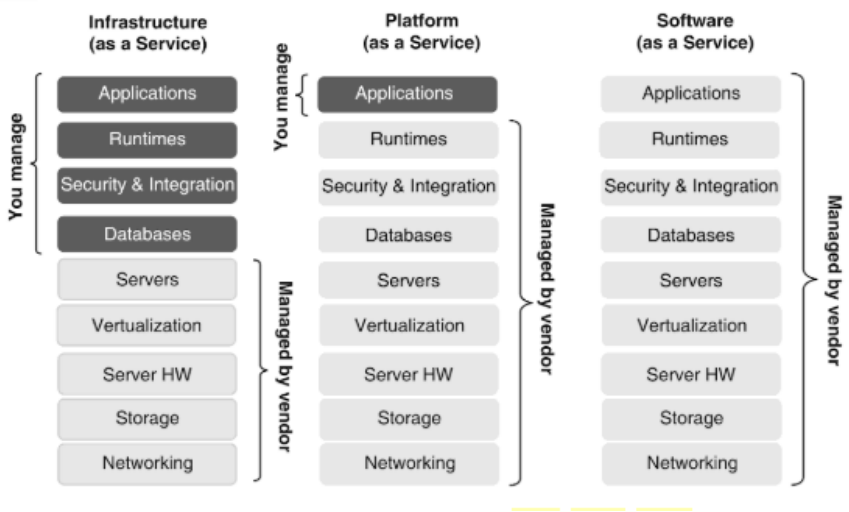


*Figure 3: IaaS, PaaS, SaaS models (Pandey & Kavita, 2014)*

### 2.2.2.2 Deployment Models

According to the NIST the Cloud has got four different ways of deployment, these models are the *Private Cloud*, *Community Cloud*, *Public Cloud and the Hybrid Cloud.* Figure 4 shows the definition of the NIST per deployment model according to Mell & Grance (2011).

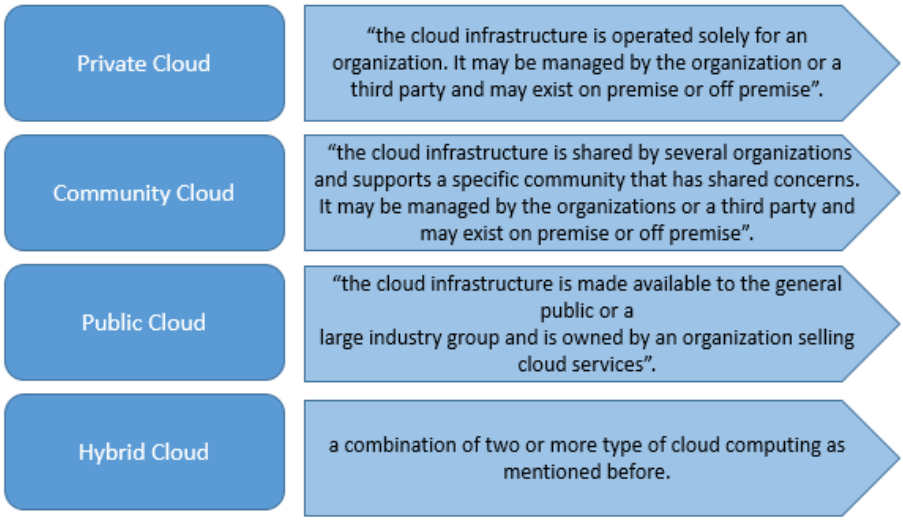


*Figure 4: Deployment models of cloud computing (Mell & Grance, 2011)*

# Chapter 3: Software as a Service

This chapter will focus on Software as a Service. First of all we will discuss the previous business models of software providers such as the COTS and the ASP business model. Thereafter we will discuss the SaaS business model, and why it is sustainable in contrast to the ASP model. Finally this chapter will discuss the perceived risks and opportunities of SaaS solutions, by analyzing multiple research papers on the topic.

## 3.1 Business models Software solutions

### 3.1.1 Commercial of the Shelf & License Software

The traditional way for software vendors to provide users with their products where to sell the Commercial of-the-shelf (COTS). These products are software applications that are designed to be easily installed and are designed to be compatible with existing system components (Ma, 2007)). These products were designed to fit the overall requirements, because making them too specific for one purpose is to costly (Ma, 2007). The business model for COTS software was such that users could buy the software (usually on a CD in a retail shop) with an End-User License Agreement (EULA). Because of this one-time payment, the investment cost for businesses are high as well as the cost for upgrades. For these reasons there where many limitations for both the vendors as the users.

### 3.1.2 Application Service Provider (ASP)

Application Service Providers were the first to overcome some of the limitations the traditional licensed software had. It started in 1998 with providers like US internetworking and Corio (Tree, 2004). The idea of ASP was to provide software without being on premise, so businesses did not have to own, manage or maintain the software or the server themselves (Ju, 2010). The Application Service providers served as brokers via a hosted model of complex enterprise software packages (Tree, 2004) being responsible for buying and maintaining the client and server software, making the software available to users through their own data center (Ju, 2010). The business model behind ASP was not a flawless one, the providers were competing with the businesses they were working with. Because they did not provide a new software package but just provide a new channel to deliver the same licensed product (Tree, 2004). Furthermore there were many other factors why ASP did not got a sustainable business model, such as difficulty to achieve scaling, because off the customization of the application to each user (Tree, 2004). Also the revenue model was not

optimal, because it was just as with the licensed model a single upfront license payment (Ju,2010) and a setup fee, and high maintenance cost(Tree, 2004). For these reasons ASP did not succeed.

### 3.1.3 Software as a Service (SaaS)

After the failure of the so called "first generation", the ASP, the second generation started in 2000 with the Software as a Service (SaaS) (Tree, 2004). As mentioned above, Software as a Service is one of the three cloud service models and is characterized as a software solution where the user does not have to install any hardware on his device, the service is bought on a subscription basis and is updated automatically without the intervention of the user (Ma, 2007). The first and still successful companies to introduce SaaS was Salesforce.com in 2000 (Cusumano, 2010), it launched a suite of online programs for business orientated tasks such as customer relationship management (CRM), the slogan of Salesforce.com was 'no-software!' which represented the new model without software on premises (Hayes, 2008). A broadly definition on SaaS is that it "is a way of delivering centrally hosted applications over the internet- as a service" (Salesforce.com). Other terminology for SaaS are On-demand software, Web-based software, or hosted software (Salesforce.com).

But how was it possible for SaaS to be successful were ASP failed? The main reason for the success of SaaS is that is has a complete new business model (MA, 2007). Where ASP and Licensing rely on a relatively high one time upfront payment, with high maintenance or upgrade costs (Ma, 2007; Ju 2010; Tree, 2004), does the business model of SaaS rely a pay per use model or with subscriptions (Vaquero, et al., 2009). This means that high quality software became available for smaller companies because they now pay a monthly fee instead of a huge upfront investment (Ma, 2007; Benlian & Hess, 2011). The SaaS business model is so that you only pay for what you use, the service is easily convertible to meet the requirements of the demand.(Benlian, & Hess, 2011) Furthermore, the SaaS solution is the easiest cloud service model to implement in a business, as shown in figure 3, the vendor manages the whole IT infrastructure, and there for the user does not have to gain any expertise or has to invest time in the software know-how (Pandey & Kavita, 2014). For these reasons SaaS has become the most adopted form of cloud computing with SMEs (Seethamraju, 2015).

## 3.2 Risk and opportunities

Adopting a new IT solutions always have perceived risks and perceived opportunities. While implementing such a technology as SaaS is a top management decision, we have analyzed a paper of Benlian & Hess (2011) who have interviewed 349 IT executives about their perceived Risk and Opportunities regarding SaaS adoption and combined their findings with finding in other papers about the perceived opportunities and risks of SaaS/cloud adoption. We have categorized the five major perceived risks and opportunities of SaaS adoption below.

### 3.2.1 Risks

The first risk that is indicated is the *performance risks*, it is the risk that SaaS cannot deliver the expected level of service. Problems that can threaten the optimal performance capabilities of the SaaS application are that the availability or network bandwidth of the application is less then was promised by the vendor. Another perceived performance risk is a problem with the Interoperability with the on premise applications. The third reason for performance risk is complete system outages or connectivity problems, this is perceived as a high value risk, because it affects all customers at once (Oliveira, Thomas & Espadanal, 2014; Benlian & Hess, 2011).

Performance risks are perceived as a high risk, while the potential losses are high. The potential losses are are high because if there is a lack of performance on the vendors side, the company cannot operate fully what does not only lead to monetary losses, but has also the risk of damaging the company's reputation. Businesses can mitigate this perceived risk with a strong Service Level Agreements (SLA) management (Benlian & Hess, 2011).

The second risk is the *Security* risk. By adopting a SaaS solution a business mitigates some or all of his data off premise to the SaaS providers data center, thereby giving all control of your data to the vendor without exactly knowing how secured the data center is and which back-up and recovery procedure is in place. The second issue with security is that businesses are unaware of current risks due to the vast changes on IT and cloud computing. Due to the vast changes vendors may use ambiguous statements and loopholes in contracts to pursue opportunistic behavior. The final security risk is the risk of data leaks or data corruption due to security breaches (Oliveira, et al., 2014; Nuseibeh, 2011; Armbrust et al. 2010; Benlian, & Hess, 2011).

The third risk of SaaS is the *Economic* risk, this is the risk that the business that uses the SaaS solution have to pay more than they initially anticipated to reach the expected service level. These hidden costs occur mainly because the vendor of the SaaS solution got the bargaining power over the user (Armbrust et al., 2010; Benlian & Hess, 2011).

The fourth risk is the *strategic risk* adopting SaaS can lead to losing critical resources and capabilities, especially when business-critical software is involved. By adopting SaaS the business user commits to a high level of independence between him and the vendor. This may decrease the ability to react quick on new internal or external business opportunities such as new business strategies or getting in to new market opportunities (Nuseibeh, 2011; Fox, et al., 2009; Benlian, & Hess, 2011).

The final perceived risk when adopting a SaaS solution into a business is the *Managerial risk or psychosocial risk*. This the risk that the reputation and career of the manager that is responsible for the application will be harmed by outsourcing the software to a external provider. This can occur due to the media that relate outsourcing often with negative events such as job loss. This may affect how clients, or staff perceive the manager and may cause a loss of power and control (Nuseibeh, 2011; Benlian, & Hess, 2011).

### 3.2.2 Opportunities

The first opportunity of SaaS adoption is a monetary one, namely *cost savings*, it is the most common and the most consistent motive to switch to a cloud solution. As mentioned earlier, ownership, maintenance, development of software lays with the vendor instead of the client. And because SaaS provide multiple users with a single instance of standardized software on a shared infrastructure, it is possible for the vendor to use a scalable and cost efficient platform. This lowers the total cost of ownership for the vendor, and lowers the price for the business user (Nuseibeh, 2011; Buyya et al., 2009; Armbrust et al. 2010; Benlian & Hess 2011).

The second perceived opportunity with SaaS adoption is that a business creates more *Strategic Flexibility*. SaaS makes switching IT providers more easily because it reduces vendor lock in, due to that the switching costs are considerably lower compared with the licensing software. Furthermore SaaS is a pay for what you use model, so it is flexible on utilization and scalability. Therefore, it is for business easy to adapt changes (Ju, et al., 2010; Fox et al., 2009, Benlian & Hess, 2011).

The third perceived opportunity is that a business can *focus itself on its core business*. SaaS adoption can free up resources due to that the vendor owns and maintain the servers, outsourcing those activities enables a firm to focus on their core business because they can use those resources more productively in areas that create value (Nuseibeh, 2011; Teng et al., 1995, Benlian & Hess 2011; Levina et al., 2003)

The fourth opportunity for SaaS adopters is that they have *access to leading-edge IT resources*. This is the main indicator of IT outsourcing success and is an important driver of the outsourcing decision. Because SaaS is based on a multi-tenant platform architecture, the vendor benefits from economies of scale by consolidation and virtualization of its data center. The business user on the other hand profits from the use of economies of skill (Benlian, & Hess, 2011).

The final opportunity is the *quality improvements,* SaaS adoption will lead to an increase in effectiveness and efficiency of the processes that the software/application supports. Due to the low switching costs it is expected that SaaS providers are more responsive to customer needs, or else risking losing the subscription revenue. For this reason the providers will incorporate best practices in to the cloud and also provide total quality management procedures such as lean management. Furthermore, SaaS business relationships between provider and customer allow an increased measurability of service quality and clear contractual specifications regarding adequate service levels, due to that they are based on key performance indicators. This characteristics allow for higher transparency than that of a on premises solution and may translate into stronger vendor discipline and better service quality (Nuseibeh, 2011; Ju, et al., 2010; Benlian, & Hess, 2011).

# Chapter 4: Cloud adoption

Cloud computing is not the first major breakthrough the industry 4.0, therefore we can look at previous ones to see how those were adopted by the market. First of all we will discuss a previous IS breakthrough that changed the whole industry including the manufacturing namely the Enterprise Resource Planning system (Buonanno et al., 2005). To see what stages it went through before it was broadly adopted in the industry. Secondly this chapter will look at what factors could influence the diffusion and adoption of Cloud solution and in particular SaaS adoption in the manufacturing industry. Two models will be used to find those influencing factors, namely Technology Organization Environment model (TOE) (Tornatzky and Fleischer, 1990) and the Diffusion of Innovation model (DOI) (Rogers, 1995). Finally we will discuss how the actual adoption process goes in the industrial market with the five dimensions of the industrial adoption process model suggested by Urban, Ozanne, Gilbert and Churchill (1971).

## 4.1 Industry 4.0 adoption: Enterprise Resource Planning

To see how the adoption process of cloud computing may go we firstly have to examine the adoption process of the ERP systems. The major ERP vendors such as SAP, JD Edwards and PeopleSoft firstly targeted the high end market, businesses with over a 1000 employees (Van Everdingen, Van Hillegersberg & Waarts, 2000). After that market started to get saturated late 90s early 00s the ERP vendors started to focus on smaller businesses, SMEs noticed the cost effectiveness of an ERP system and had a competitive necessity to follow suit (Klaus et al., 2000). Literature shows that there are some key issues that were critical for the ERP adoption by SMEs. First of all the ERP system had to fit with the current business processes, this was the most important selection criteria (Van Everdingen, et al., 2000). Furthermore, literature shows that non-adopting SMEs did not discard ERP systems for financial reasons, suggesting that organizational and structural reasons are more important indicators for the decision to adopt an ERP system (Buonanno et al., 2005). Literature also shows that a short implementation time is highly important (Van Everdingen, et al., 2000) this is because the decision process regarding the adoption of an ERP system for SMEs is most affected by "the opportunity of the moment" (Buonanno et al. 2005). ERP is still an evolving system, the next step to target the non-adopters in the SME market was an ERP system as a SaaS solution. It is considered the best opportunity for SMEs to take full advantage of an ERP system without the costs of an on premise ERP system and without the management costs (Seethamraju, 2015). These statements about ERP are very similar as the

statements that are made about cloud computing earlier this paper, and that is one of the reasons that we will look at the adoption of ERP systems so we can look if there are similarities between the adoption process ERP has made an in which direction SaaS adoption is going.

## 4.2 What factors influence cloud adoption?

Adopting IT innovations can play an important role in getting competitive advantage, the willingness to adopt new IT innovations such as SaaS can vary from person to person, from business to business. Factors that can influence the need to adopt new IT solution are external competitive factors and internal organizational factors, such as: internal processes, firm size, the nature and extent of use after implementation and changes the new system enables for the firm. The technology innovation itself of course plays a huge part in the willingness of adoption as well (Seethamraju, 2015). When looking at the literature there are many theories that address the subject of IT innovation adoption, such as the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh, Morris, Davis & Davis, 2003), the Theory of Planned Behaviour (TPB) (Ajzen, 1991), the Technology Acceptance Model (TAM) (Davis, Bagozzi & Warshaw, 1989), the Technology Organization Environment (TOE) framework (Tornatzky and Fleischer, 1990) and the Diffusion of Innovation (DOI) theory (Rogers, 1995). This paper will focus on the TOE framework and the DOI theory, for the reason that those are the only ones that focus on IT/IS adoption at firm level. UTAUT, TPB and TAM are focused on at an individual level (Oliveira and Martis, 2011).

### 4.2.1 Diffusion of Technology

The Diffusion of Technology (DOI) theory focuses on how, why and at what rate new technology spreads on individual and organizational level (Oliveira and Martis, 2011). It states that the organizational innovativeness and the willingness to adopt and implement new IT innovations depends on three characteristics, Individual Characteristics, Internal Characteristics and External characteristics. Rogers (1995) specified each characteristic as followed: 1) “The Individual (leader) characteristics defines the attitude toward change from the leader (of a business)” (Oliveira and Martis, 2011). 2) The internal characteristics of organizational structure, includes observations about: Centralization: “the degree to which power and control in a system are concentrated in the hands of a relatively few individuals”, Complexity: “the degree to which an organization’s members possess a relatively high level of knowledge and expertise”, Size: “the number of employees of the organization”, Formalization: ”he degree to which an organization emphasizes

its members' following rules and procedures" , interconnectedness: "the degree to which the units in a social system are linked by interpersonal networks" and organizational slack: "the degree to which uncommitted resources are available to an organization" (Rogers, 1995; Oliveira and Martis 2011). 3) The External characteristics of the organization describes the System openness (Rogers, 1995; Oliveira and Martis, 2011)). Figure 5 shows the model of the DOI theory.

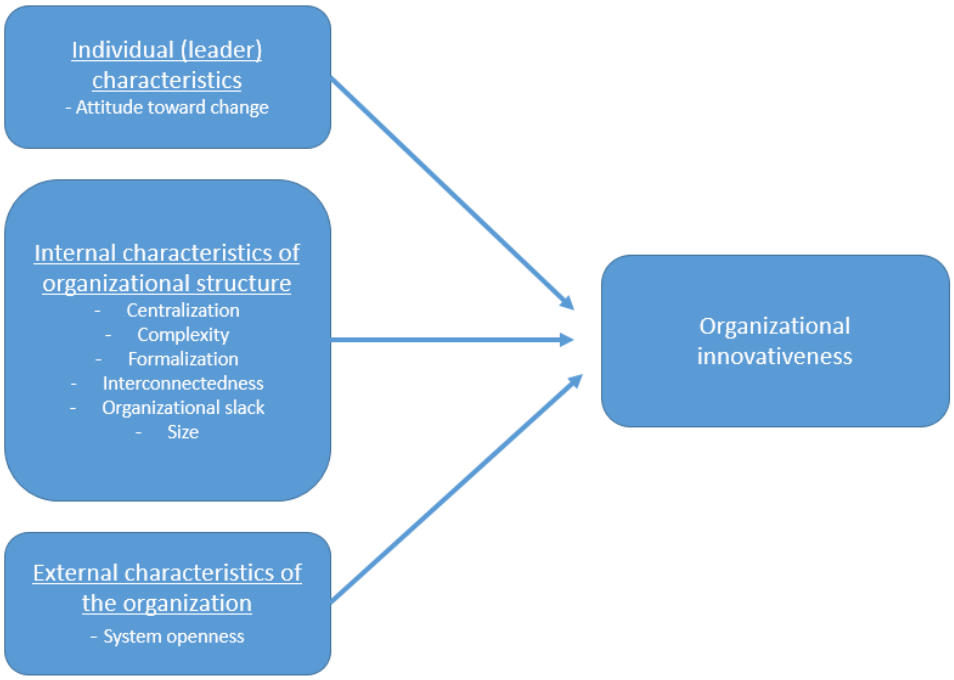


*Figure 5: The Diffusion of Technology model (Rogers, 1995)*

### 4.2.2 Technology, Organization, Environment framework

In 1990 Tornatzky and Fleischer developed the Technology, Organization, Environment (TOE) framework, it distinct three aspects of an enterprise that affects the process by which the company adopt and implement a technological innovation. The three components as the name of the framework suggest are Technology, the Organization and the external Environment (Tornatzky and Fleischer, 1990). See figure 6. 1) Technology describes the context of the external and internal technologies that are relevant to the firm (Tornatzky and Fleischer, 1990). Internal technology means best practices and current equipment at the company, External technology means the set of external technology available to the company (Oliveira and Martis, 2011). 2) Organization describes the context of descriptive measures defining the company (Tornatzky and Fleischer, 1990), such as size, scope and managerial structure (Oliveira and Martis, 2011). 3) The Environment component describes the context in which the company conducts his business

(Tornatzky and Fleischer, 1990), such as their competitors, the industry and government regulations (Oliveira and Martis, 2011).

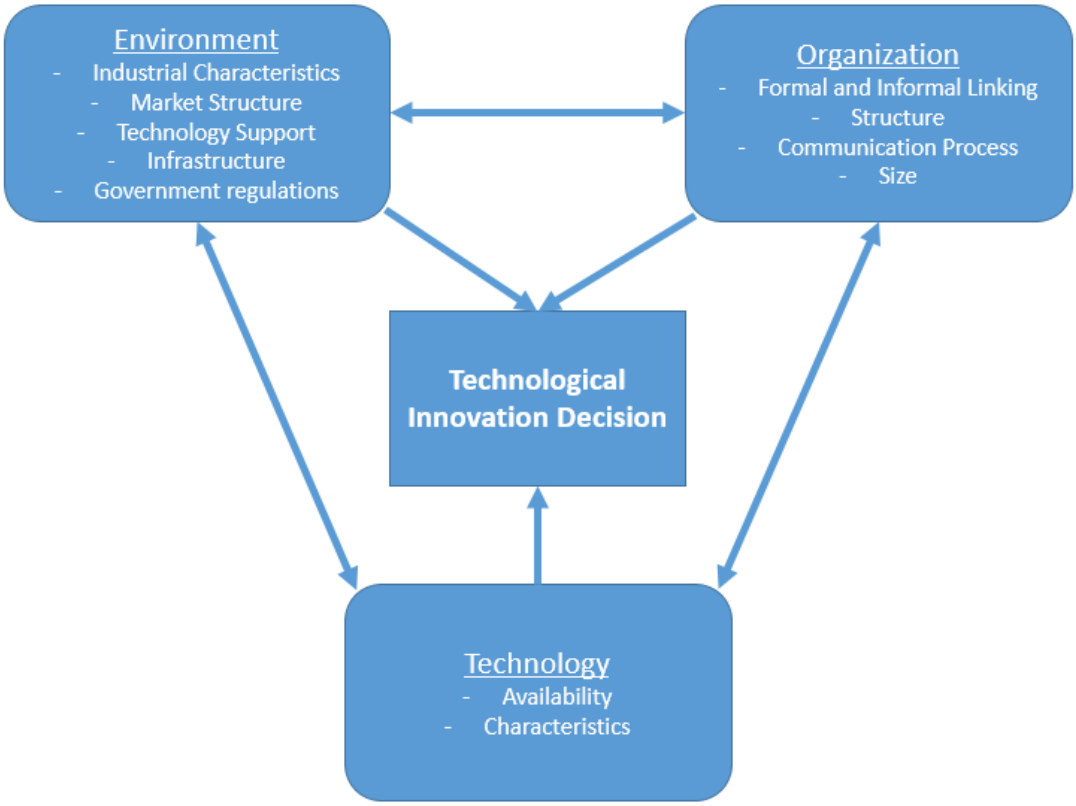


*Figure 6: The TOE model (Tornatzky and Fleischer, 1990)*

The Organizational context and the Technology context of TOE framework are identical to the individual characteristics and the internal and external characteristics of the DOI theory (Oliveira and Martis, 2011). The TOE framework includes a third component namely the Environment context, this is an important component because it presents both opportunities and constraints for the Technological Innovation (Oliveira and Martis, 2011). Literature shows that the DOI theory in combination with the TOE framework therefor is the most widely used model to research and understand the adoption and implementation process of IT innovations (such as SaaS) (Oliveira, Thomas, & Espadanal 2014; Oliveira and Martis, 2011; Seethamraju, 2015).

## 4.3 The industrial adoption process.

The five dimensions of industrial adoption process model suggested by Urban et al.(1971), is a model that suggest that after the company is aware of the new technology and is willing to adopt

it (outcome of the TOE/DOI model) a company goes through five stages before it adopts the new technology or chooses to discontinue. When a company is aware of the need for the new technology it will follow a similar process as the consumer adoption process where it searches for more information in each stage. First of all they will use impersonal sources such as advertising and technical brochures to evaluate if the perceived rewards are more than the perceived costs. If this is true for the case the will investigate more thoroughly with personal sources, this is to define the users experience. Before adopting and implementing, a new technology a trial version is used to identify if the vendor meets the requirements they have in mind (Urban. et al., 1971). See figure 7 for a complete overview of the model.

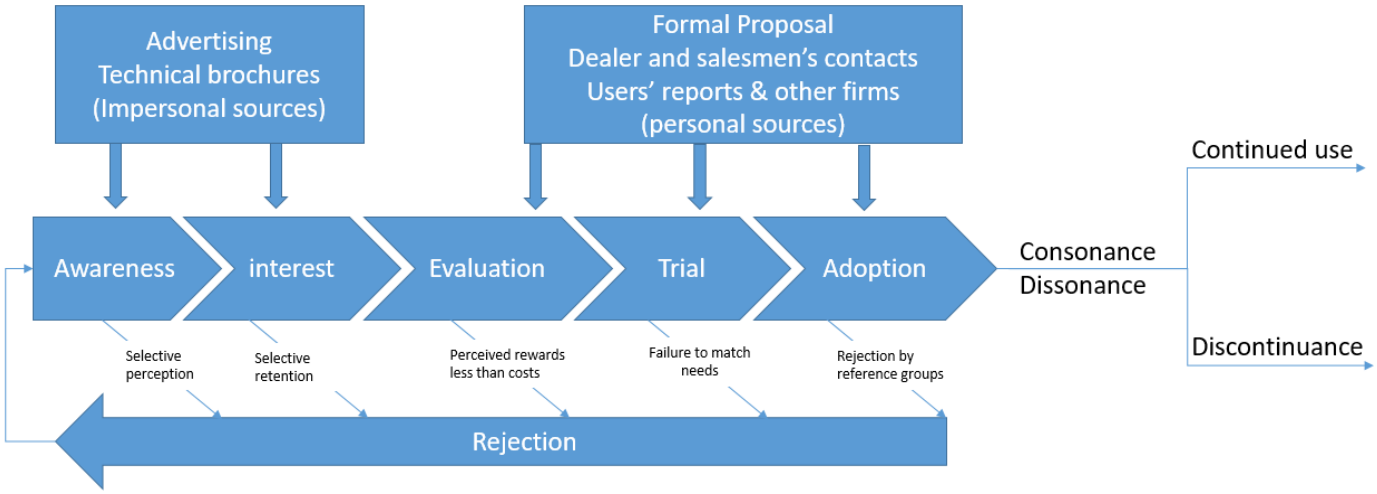


*Figure 7: The Industrial adoption process (Urban et al., 1971)*

# Chapter 5 Research Design

To research the problem statement mentioned above we will use mixed methods to come to our findings. This paper will use three steps to investigate the adoption of SaaS by SMEs in the manufacturing industry. First of all we use a survey to see which factors influence the adoption of SaaS in the manufacturing industry.

Secondly we design an experiment that looks for a correlation between SaaS adoption and a change in value in SMEs in the manufacturing industry. We expect that if there is a positive correlation between the change in company's value and the adoption of SaaS, this will influence top managers' perception of risk vs opportunities in favor of opportunities. This assumption will be tested with the survey as well.

Thirdly we will compare the current SaaS adoption with the ERP adoption to see if they follow the same adaptation trajectory so we may provide a future trajectory of the SaaS implementation process.

The unit of analysis for this research will be SMEs in the manufacturing industry, furthermore we will use a longitudinal time horizon, while we want to see how SaaS adoption influenced the SMEs in comparison to the non-SaaS adopters over time.

## 5.1 The Survey

First of all we will design a survey that will be send out to the chief information officers (CIO's) of SMEs in the manufacturing industry across the world. We send this survey with two reasons, first of all because we need to know which SMEs have adopted a SaaS solution and which SMEs have not, this is necessary for our experiment in step two. The second reason we use the survey is that we can determine our TOE/DOI framework with a questionnaire, so we can research and understand the adoption and implementation process of IT innovations in the manufacturing industry (Oliveira, et al., 2014; Oliveira and Martis, 2011; Seethamraju 2015). Furthermore, we will use the survey to determine if the top managers perspective towards Risk vs. Opportunity changes if SaaS adoption led to a positively change in the value of the company. Literature shows that the response rate for published studies that collect data from organizations is 35.7% with a standard deviation of 18.8 (Baruch & Holtom, 2008), we expect that our response rate will be lower than published work, therefore we plan to sends out our survey our survey to a sample of 6000 SMEs. First we divide our target population (SMEs in the manufacturing industry) into six

strata, representing the six continents (Antarctica is excludes in this research while it has no SMEs). Secondly we take a random sample of 1000 SMEs in each strata to which the survey is sent.

## 5.2 The experiment

Secondly we will look if there is a causality between SaaS adoption by SMEs in the manufacturing industry and the change in value over time. The first thing we need to do to answer that question, is to define value. Value has multiple definitions, but in its most broadly way it can be defined as "The regard that something is held to deserve; the importance, worth, or usefulness of something" ("value | Definition of value in English by Oxford Dictionaries"). Because this is an abstract definition that can be interpreted by individuals in a different manners, we choose for this experiment to measure the value of a SME by two topics. The first measurement comes by the definition of value as "The material or monetary worth of something" ("value | Definition of value in English by Oxford Dictionaries"). Therefore we will examine the company's net worth over time. The second measurement we take to measure a change in value is the company's performance over time, this can be measured using the company's Return on Assets (ROA), its Return on Investment (ROI) and its Return on Sales (ROS) (Hunton, Lippincott & Reck, 2003). We choose to use these measurements because of the opportunities mentioned earlier that SaaS adopters have. These opportunities are cost savings, strategic flexibility, focusing on core business, access to leading-edge IT resources and quality improvements. We believe those opportunities lead to competitive advantages that must be seen in either the monetary value of a company and/or in their performance (Hunton et al., 2003).

Secondly we will divide the survey respondents in to two new strata, adopters of SaaS solutions (experimental group) and non- adopters of SaaS solutions (control group), and draw a random sample of at least 60 per strata according to the rules of thumb (VanVoorhis & Morgan, 2007). For the experimental group we will investigate financial statements of the past 10 years to see how their Return on Assets, Return on Investments and their Return on Sales is have changed, we derived this from the study of Hunton, et al. (2003) who used these criteria so examine the impact of an ERP system between adopters and non-adopters, moreover we will compare the Net worth of the company in the same time frame. With these factors we will derive if the value of the company has changed due to the implementation of SaaS. For the control group we examine the same time period for the same factors to see if there is a correlation between SaaS adoption and the change of company value, or that other factors may have influenced this.


*Figure 8: conceptual model of the experiment.*

## 5.3 The adoption trajectory

Our final step is to compare the SaaS adoption process with the ERP adoption process, to see if SaaS follows the same trajectory as ERP. This may be important information for future research and from a managerial aspect it can help SMEs plan future investments. We plan to compare our finding from the questionnaire and the experiment to earlier research on the ERP adoption process such as the research of Buonanno, et al. (2005); Law & Ngai (2007), Hwa Chung & Snyder, (2000), and Van Everdingen, et al. (2000).

# Chapter 6: Conclusion, Limitations and future research

This chapter will conclude this research paper on SaaS adoption by SMEs in the manufacturing industry. First of all it will it will derive a final conclusion from the papers findings. Secondly it will provide the limitations this research has, and finally it will give some food for thought for future research.

## 6.1 Conclusion

In this paper we have looked at the adoption process of SaaS solutions by SMEs in the manufacturing industry. First of all we have defined the domain, Industry 4.0, from which we have included ERP systems and the Cloud in our scope. Secondly we have concluded that the success factor of SaaS was the new business model, where consumers can benefit forma leading edge IT resources without a huge upfront investment, but on a subscription base. Thirdly we have done a risk and opportunity assessment from a perceived management perspective, from which we can deducted that the opportunities of SaaS adoption can give SMEs a competitive advantage. To test these findings we have designed a experiment where we compare the change in value between SaaS adopters and non-SaaS adopters, to see whether there is a correlation between change in value and the adoption of SaaS. Finally we have tried to see if there are similarities between the ERP adoption process and the SaaS adoption process, so managers can plan the next steps of the adoption process.

## 6.2 Limitations

The foremost limitation of this paper is that we did not execute the survey or experiment. Therefore, we had to make assumptions such as that top management is positively influenced by a correlation if SaaS adoption and value change. Other assumptions about the DOI and TOE framework had to be derived from previous research, while we did not have any primary data. Other limitations come from the fact that we do not know if Cloud adoption follows the same trajectory as ERP adoption has followed.

## 6.3 Future research

It will be interesting for future researches to see if the SaaS adoption follows indeed the same trajectory as the ERP adoption did. We are only at the beginning of the fourth industrial revolution, so we do not yet know which new IT/IS innovations are around the corner. If we can establish a new innovation adoption model, instead of the models that where created before industry 4.0 had arrived, it could mean a more accurate prognose of adaptation of the new innovation.

## Bibliography:


- Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes, 50(2), 179-211*.
- Alshamaila, Y., Papagiannidis, S., & Li, F. (2013). Cloud computing adoption by SMEs in the north east of England: A multi-perspective framework. *Journal of Enterprise Information Management, 26(3), 250-275.*
- Armbrust, M., Fox, A., Griffith, R., Joseph, A. D., Katz, R., Konwinski, A., ... & Zaharia, M. (2010). A view of cloud computing. *Communications of the ACM, 53(4), 50-58.*
- Ayyagari, M., Demirgüç-Kunt, A., & Beck, T. (2003). Small and medium enterprises across the globe: a new database. *The World Bank.*
- Baruch, Y., & Holtom, B. C. (2008). Survey response rate levels and trends in organizational research. *Human relations, 61(8), 1139-1160.*
- Benlian, A., & Hess, T. (2011). Opportunities and risks of software-as-a-service: Findings from a survey of IT executives. *Decision Support Systems, 52(1), 232-246.*
- Bhardwaj, S., Jain, L., & Jain, S. (2010). An approach for investigating perspective of cloud Software-as-a-Service (SaaS). *International Journal of Computer Applications, 10(2), 40-43.*
- Buonanno, G., Faverio, P., Pigni, F., Ravarini, A., Sciuto, D., & Tagliavini, M. (2005). Factors affecting ERP system adoption: A comparative analysis between SMEs and large companies. *Journal of Enterprise Information Management, 18(4), 384-426.*
- Buyya, R., Yeo, C. S., Venugopal, S., Broberg, J., & Brandic, I. (2009). Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility. *Future Generation computer systems, 25(6), 599-616.*
- Cusumano, M. (2010). Cloud computing and SaaS as new computing platforms. *Communications of the ACM, 53(4), 27-29.*
- Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: a comparison of two theoretical models. *Management science, 35(8), 982-1003.*

- Dillon, T., Wu, C., & Chang, E. (2010, April). Cloud computing: issues and challenges. *In Advanced Information Networking and Applications (AINA), 2010 24th IEEE International Conference on (pp. 27-33). IEEE.*
- Fox, A., Griffith, R., Joseph, A., Katz, R., Konwinski, A., Lee, G. & Stoica, I. (2009). Above the clouds: A berkeley view of cloud computing. *Dept. Electrical Eng. and Comput. Sciences, University of California, Berkeley, Rep. UCB/EECS, 28(13), 2009*.
- Goscinski, A., & Brock, M. (2010). Toward dynamic and attribute based publication, discovery and selection for cloud computing. *Future generation computer systems, 26(7), 947-970.*
- Gupta, P., Seetharaman, A., & Raj, J. R. (2013). The usage and adoption of cloud computing by small and medium businesses. *International Journal of Information Management, 33(5), 861-874.*
- Hayes, B. (2008). Cloud computing. *Communications of the ACM, 51(7), 9-11.*
- Henderson, J. C., & Venkatraman, H. (1993). Strategic alignment: Leveraging information technology for transforming organizations. *IBM systems journal, 32(1), 472-484.*
- Hunton, J. E., Lippincott, B., & Reck, J. L. (2003). Enterprise resource planning systems: comparing firm performance of adopters and nonadopters. *International Journal of Accounting information systems, 4(3), 165-184.*
- Hwa Chung, S., & Snyder, C. A. (2000). ERP adoption: a technological evolution approach. *International Journal of Agile Management Systems, 2(1), 24-32.*
- Jacobs, F. R. (2007). Enterprise resource planning (ERP)—A brief history. *Journal of Operations Management, 25(2), 357-363.*
- Ju, J., Wang, Y., Fu, J., Wu, J., & Lin, Z. (2010, June). Research on key technology in SaaS. In Intelligent Computing and Cognitive Informatics (ICICCI), *2010 International Conference on (pp. 384-387). IEEE.*
- Klaus, H., Rosemann, M., & Gable, G. G. (2000). What is ERP?. *Information systems frontiers, 2(2), 141-162.*

- Kushnir, K., Mirmulstein, M. L., & Ramalho, R. (2010). Micro, small, and medium enterprises around the world: how many are there, and what affects the count. *Washington: World Bank/IFC MSME Country Indicators Analysis Note, 1-9.*
- Lasi, H., Fettke, P., Kemper, H. G., Feld, T., & Hoffmann, M. (2014). Industry 4.0. *Business & Information Systems Engineering, 6(4), 239-242.*
- Law, C. C., & Ngai, E. W. (2007). ERP systems adoption: An exploratory study of the organizational factors and impacts of ERP success. *Information & Management, 44(4), 418-432.*
- Levina, N., & Ross, J. W. (2003). From the vendor's perspective: exploring the value proposition in information technology outsourcing. *MIS quarterly, 331-364.*
- Low, C., Chen, Y., & Wu, M. (2011). Understanding the determinants of cloud computing adoption. *Industrial management & data systems, 111(7), 1006-1023*.
- Lu, Y. (2017). Industry 4.0: A survey on technologies, applications and open research issues. *Journal of Industrial Information Integration, 6, 1-10.*
- Ma, D. (2007, July). The business model of" software-as-a-service". *In Services Computing, 2007. SCC 2007. IEEE International Conference on (pp. 701-702). IEEE.*
- Mell, P., & Grance, T. (2011). The NIST definition of cloud computing.
- Nuseibeh, H. (2011, August). Adoption of Cloud Computing in Organizations. *In AMCIS.*
- Oliveira, T., & Martins, M. F. (2011). Literature review of information technology adoption models at firm level. Electronic Journal of Information Systems Evaluation, 14(1), 110.
- Oliveira, T., Thomas, M., & Espadanal, M. (2014). Assessing the determinants of cloud computing adoption: An analysis of the manufacturing and services sectors. *Information & Management, 51(5), 497-510.*
- Olsthoorn, S., & Verbeek, J. (2018, 11 juni). Afas geeft klant geen keus meer: iedereen moet de cloud in. *Het Financieel Dagblad (FD), p. 12. Geraadpleegd van https://www.afas.nl/file/download/default/A37023D14B6BD482E5B6BBA5DB65AAE6/fd%20cloud.pdf*

- Ozanne, U. B., & Churchill Jr, G. A. (1971). Five dimensions of the industrial adoption process. *Journal of Marketing Research, 322-328.*
- Pandey, U. S., & Kavita, C. (2014). Cloud computing. *S. Chand Publishing. Page 88.*
- Rogers, E. (1995). Diffusion of Innovation. *New York: The Free Press.*
- Salesforce.com. What is Software as a Service (SaaS) - *Salesforce.com. Retrieved from https://www.salesforce.com/saas/*
- Seethamraju, R. (2015). Adoption of software as a service (SaaS) enterprise resource planning (ERP) systems in small and medium sized enterprises (SMEs). *Information systems frontiers, 17(3), 475-492.*
- Sverdlik, Y. (2017, 7 December). Biggest Enterprise Software Will Soon Be SaaS-Only and It's Time to Worry. *Retrieved from https://www.datacenterknowledge.com/cloud/biggest-enterprise-software-will-soon-be-saas-only-and-it-s-time-worry*
- Teng, J. T., Cheon, M. J., & Grover, V. (1995). Decisions to outsource information systems functions: testing a strategy-theoretic discrepancy model. *Decision Sciences, 26(1), 75-103.*
- The Economist Intelligence Unit, "Ascending Cloud: The Adoption of Cloud Computing in Five Industries," *The Economist, 2016*
- Tornatzky, L. G., Fleischer, M., & Chakrabarti, A. K. (1990). The processes of technological innovation. *Issues in organization and management series. Lexington Books.*
- Tree, T. (2004). Software as a Service: Changing the Paradigm in the Software Industry. *Software & Information Industry Association (SIIA) and TripleTree.*
- value | Definition of value in English by Oxford Dictionaries. *Retrieved from https://en.oxforddictionaries.com/definition/value*
- Van Everdingen, Y., Van Hillegersberg, J., & Waarts, E. (2000). Enterprise resource planning: ERP adoption by European midsize companies. *Communications of the ACM, 43(4), 27-31.*

- VanVoorhis, C. W., & Morgan, B. L. (2007). Understanding power and rules of thumb for determining sample sizes. *Tutorials in Quantitative Methods for Psychology, 3(2), 43-50.*
- Vaquero, L. M., Rodero-Merino, L., Caceres, J., & Lindner, M. (2008). A break in the clouds: towards a cloud definition. *ACM SIGCOMM Computer Communication Review, 39(1), 50-55.*
- Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS quarterly, 425-478.*
- Wang, L., Von Laszewski, G., Younge, A., He, X., Kunze, M., Tao, J., & Fu, C. (2010). Cloud computing: a perspective study. *New Generation Computing, 28(2), 137-146.*
- What is ERP | Enterprise Resource Planning Definition | SAP. . *Retrieved from https://www.sap.com/products/what-is-erp.html*