University of Leiden

ICT in Business and the Public Sector

Modelling of Software Package Implementation: A Case Study

Name: Rutger Kerckhoffs
Student-no: s2325888

Date: 30/03/2021

1st supervisor: Pieter Kwantes
2nd supervisor: Werner Heijstek

MASTER'S THESIS

Leiden Institute of Advanced Computer Science (LIACS)
Leiden University
Niels Bohrweg 1
2333 CA Leiden
The Netherlands

Preface

This thesis was written for the master ICT in Business & the Public Sector as a final test of competence. Before going into the contents of this thesis, I would first like to thank the people that helped me with the writing of this thesis. To start off with I would like to thank my first university supervisor Pieter Kwantes for his enthusiasm about the subject, his expertise, and the useful feedback he provided me with. My thanks also go out to my second university supervisor Werner Heijstek. Finally, I would like to thank the company that was subject to this case study: ProActive, with a special thanks to Lars van der Meer and Manon Yassa for providing me with guidance throughout the process and allowing me to access their extensive dataset which was very useful for this research.

Abstract

There is a general consensus among managers and literature that software package implementations (SPI) have a shorter implementation lead time than customized software implementations. However, SPI's are often undertaken with unrealistic expectations and minimal understanding of the tasks needed, which results in a failure to meet deadlines. In this research, current approaches to address this problem are evaluated by means of a literature review. Hereby, it is argued that these approaches are often too generic to be able to provide a concrete solution in a specific business setting. Thus, to improve on existing approaches, a quantitative approach to modelling lead time distribution at company level is proposed, by applying machine learning technology on local company data. The resulting model is tailored to include company specific factors, to serve the needs of local stakeholders. In particular, this model can be used to improve prediction of SPI lead time and to identify opportunities for decreasing SPI lead time.
The feasibility of this approach is demonstrated by executing a case study at a software package supplier. This case study included the development of a regression tree model using data from the software package supplier's project administration for training and test set. Lastly, on the basis of the evaluation of the regression model, extensions to the project administration are proposed that can improve the predictive performance of the model.

Table of Contents

List of Figures

List of Tables

1 Introduction

1.1 Problem Statement

In software implementation[1] projects, there are generally two different types of software products that can be implemented: packaged software, where a standard software system is developed for a more general public; or customized software, where software is developed for a specific customer. Software package implementations (SPI's) generally have shorter lead times and lower costs than customized software implementations (Lucas et al, 2014). Therefore, organizations that intend to automate some of their organizational processes in a short time frame tend to go for a software package solution. However, these type of implementation projects are often undertaken with unrealistic expectations and minimal understanding of the tasks needed, which results in the implementation not being finished in an as short of a time frame as expected (Tayntor, 2007).

"*When a software projects is successful, it is not because there were no problems but because the problems were overcome" – Paul Rook.* Every software project has similar potential problems, for example: a lack of resources, resistance to change, lack of team experience/knowledge, etc. (Schmidt et al, 2001). If these potential problems are not addressed properly, they can become real problems that negatively impact important project factors, such as implementation lead time (Fairley, 2009). This is a problem, because a longer implementation lead time often leads to higher costs, lower productivity[2], and a lower customer satisfaction, compared to a similar project with a shorter implementation lead time (Fairley, 2009).

1.2 Research Question

The problems of budget and deadline overruns in software development projects have been extensively investigated since the software crisis in 1968 (Jorgensen et al, 2008). Some of the approaches proposed to address these problems were based on the formal modelling of software effort based on empirical data[3](Jorgensen et al, 2008). These formal models enabled researchers to uncover relevant patterns in their gathered data during software development and increase the understanding and the predictability of software development projects (Jorgensen et al, 2008).

Buyers of software packages would in theory not encounter the problems associated with developing customized software. Nevertheless, as mentioned above, in many cases, SPI's can also encounter problems like schedule overruns. However, a mature framework for modelling the lead time of SPI's appears to be missing (Vogelezang et al, 2012). This leads to the following main research question: "*How can a data driven and quantitative modelling approach increase the predictability of SPI lead time and identify opportunities to reduce SPI lead time in a concrete business setting?"*

---

[1] Software implementations are projects where a software system is integrated within an organization.
[2] When a company's average implementation lead time is longer, they can finish less projects in a specific period of time compared to when the average implementation lead time would be shorter.
[3] For example: Boehm with COCOMO, Capers Jones with FPA, etc. (Sami, 2018)

1.3 ProActive Software Netherlands B.V.

The company that will serve as the concrete business setting in this research is ProActive Software Netherlands B.V.
ProActive is a Dutch software company that produces the "SPEND Cloud". The company has an establishment in Haarlem and employs around 43 FTE in 2020. In 2018, they had a revenue of 6,6 million euro's.

The SPEND Cloud is an in-house designed packaged purchase-to-pay (P2P) system. ProActive claims that it offers a complete Software-as-a-Service (SaaS) solution for all business expenses of a company by providing one central overview of all expenditures. The system consists of five different modules: invoice processing, procurement, contract management, expense claims, and the cash & card module.

The SPEND Cloud is implemented at customers by ProActive's consultants. The role of these consultants in the implementation is to configure and deliver the system according to the specific customer's demands. These implementations do not generate profit and only result in non-recurring revenue for ProActive. ProActive believes their profit should come from the license fees they charge to their customers for making use of their product, because this results in recurring revenue.

One of the main goals of ProActive's implementation process is to finish the implementation as quickly as possible. They believe that next to customer satisfaction[4], implementation lead time is the most important element in achieving implementation success. ProActive thinks an implementation with a lower lead time is generally more successful than a similar implementation with a higher lead time for four different reasons:

1. It should be less costly
2. It makes it possible to do more projects in a specific time period
3. It should have a higher customer satisfaction as a result
4. As soon as the project is finished, ProActive can start charging their license fees to the customer. This means the earlier the implementation is finished, the sooner ProActive starts making a profit on a specific project.

However, ProActive feels like a significant number of projects they do have a higher implementation lead time than what should be possible. ProActive does not have a maximum amount of time they think the implementation should take. However, if a project is not finished within twelve months, and they can prove the customer is responsible for this above average implementation lead time, ProActive starts charging their license fees to the customer even though the implementation is not finished yet. They do this because ProActive thinks twelve months is a lead time that is way longer than what should be possible for all implementation projects.

Furthermore, to get an indication of when ProActive thinks the implementation lead time is higher than it should be, they provided a list of projects they were satisfied about, and a

[4] The specific subject of customer satisfaction is out of scope for this research. However, because customer satisfaction is generally considered as one of the main elements in achieving implementation success, this element was kept in mind when recommendations about the implementation lead time were provided.

list of projects they were less satisfied about. The maximum lead time of a project that was mentioned as successful was four months, and the minimal lead time of a project that was mentioned as less successful was six months. This does not prove that the average implementation lead time could be shorter, but ProActive's average implementation lead time is 5.85 months, which is close to the six months of a less successful project. Also, there are several projects in the dataset that took longer than twelve months. This shows ProActive is an example of a software package supplier that is dealing with our previously described research problem.

1.4 Sub-Questions

Implementation lead time is the time that passes by between the start and the end of a process. This lead time is a function of the duration of the tasks of a process and the process structure. For this reason, it is also important to understand this process structure. This will be reflected in the sub-questions (SQ's) below:

1. What approaches to the modelling of the process- and lead time distribution of P2P implementations and other SPI's can be found in previous literature?
    a. What process models of SPI's are available in previous literature?
    b. What are the most important factors that influence SPI lead time distribution, according to previous literature?
2. How are the process models that were derived from previous literature comparable to ProActive's P2P implementation process?
    a. What are the different standardized steps in ProActive's implementation process?
    b. How do these steps compare to the steps of the process that was derived from previous literature?
3. About the actual lead time at ProActive:
    a. What is its actual distribution?
    b. How is it divided across the different steps in ProActive's process?
4. What are the most important factors that influence ProActive's implementation lead time?
5. How can a quantitative model of the implementation lead time distribution at ProActive be defined?
6. How can ProActive use the described models:
    a. To predict their implementation lead times?
    b. To improve their implementation lead times?

1.5 Research Approach

In this section, it will be described for every different SQ what approach will be used to find an answer to it.

1.5.1 SQ 1

We first looked in existing literature for papers on SPI process models (SQ 1a). Hereby, a specific SPI process that was found in previous literature was modelled. Hereafter, it was determined what the most important factors are that influence the implementation lead time of an SPI process (SQ 1b). Seventeen different papers on SPI's were analysed and the factors that came forward as 'most important' out of these papers were described. Also, on the basis of these seventeen different researches, it was determined how these factors influence the implementation lead time and what the specific impact is these factors have on the lead time. SQ 1b was then answered by incorporating these findings in a 'literature model' at the end of the theoretical framework.

1.5.2 SQ 2

After the theoretical framework, the different steps of ProActive's SPI process were modelled and analysed, to see how ProActive's process compares to the specific process that was modelled in the theoretical framework (SQ 2). This comparison made it possible to assess how the findings from the theoretical framework were applicable to ProActive.

Also, on the basis of ProActive's process description, the project administration of ProActive could be described. This formed the basis for the data analysis of this research, because the registered start- and end date of a project in the project administration determine the implementation lead time of a project.

1.5.3 SQ 3

Analysing ProActive's process also opened up the possibility to address SQ 3a and 3b. How the lead time is divided across the different steps in ProActive's process (SQ 3b) was determined by looking at the lead time average of the different phases of the process. Also, the bottleneck in the process was determined by looking at what phase in the process has the highest average lead time.

1.5.4 SQ 4

After analysing ProActive's implementation process, empirical data that could later be used to assess the importance of the different factors in the context of ProActive was collected and prepared. We first looked how the factors from the literature model were present in ProActive's process, by operationalizing the factors from literature that could be analysed with existing data from the project administration. Hereafter, the problem of missing data was addressed. All cases with incomplete data were removed from the dataset. Then, the missing data about factors that could not be operationalized with the original project administration was collected with interviews and surveys. These interviews also opened up the opportunity to find out what factors the interviewees deemed to be the most important. Moreover, the interviews made it possible to take a closer look on why a specific interviewed case had a different lead time than another interviewed case.

The set of cases without incomplete data was then used for an exploratory analysis, to see what the potential company specific factors[5] are that could influence ProActive's implementation lead time. This was done by dividing the different projects in the dataset in different groups based on specific attributes of the different projects, and by looking at how the average lead time differed between these different groups.

The factors that were found in the theoretical framework and the company specific factors were then used to formulate hypotheses with. To be able to test the hypotheses, again different groups of data were created based on specific attributes of the different projects, to see how the average implementation lead time of a group with a specific attribute

[5] Factors that are important for ProActive even though they did not come forward out of the theoretical framework.

differed from the average implementation lead time of a group without that specific attribute. For example, the average implementation lead time of all projects where customization was required was compared to the average implementation lead time of all projects where customization was not required. This analysis was conducted to get an indication of the impact of a specific factor on the implementation lead time of ProActive.

The differences in average implementation lead times between the different groups were then tested on significance with the Two-Sample T- and One-Way ANOVA tests. The results of these significance tests were used to develop a qualitative model of ProActive's lead time distribution, which showed what the most important factors are that influence ProActive's lead time. The relative importance of these different factors was then quantified by using random forest[6]. This relative importance was used, together with the hypothesis testing results, for answering SQ 4. The answer to SQ 4 was also compared to the literature model, to assess the applicability of the findings from the theoretical framework in a specific business setting.

1.5.5 SQ 5

Next to quantifying the relative importance of the different factors, random forest was also used to develop a quantitative model of ProActive's implementation lead time distribution. However, the random forest approach only leads to reliable results if no *multicollinearity*[7] is present in the forest.

To check if multicollinearity was present between the different independent variables, the Spearman correlation coefficient was calculated. Hereby, all data is ordered from high to low, and based on how close the ranks of two different variables are to each other, a Spearman correlation coefficient between -1.00 and 1.00 is returned, where -1.00 is a perfect negative correlation between the two variables, 1.00 is a perfect positive correlation, and 0 indicates no correlation (Zar, 2005). Eventually, the factors that had a significantly high Spearman correlation coefficient with one or more other factors were omitted in the random forest calculations, to ensure that reliable results would be returned.

Then, the quantitative model of ProActive's lead time distribution was developed based on random forest regression.

1.5.6 SQ 6

How ProActive can use the described models to predict their implementation lead times was determined based on the random forest regression performance (SQ 6a). How ProActive can use the models to decrease their average implementation lead time was determined on the basis of what factors ProActive does have an influence on, and what factors ProActive cannot influence. By separating these 'influenceable' factors from the 'uninfluenceable' factors, ProActive can see where it is possible to take action, and where it is not possible. Lastly, recommendations were provided on the basis of the lessons learned from the theoretical framework and the interviews, in able to answer SQ 6b.

[6] Random forest is a machine learning algorithm that builds multiple decision trees and merges them together to get a more accurate and stable prediction (Donges, 2019).

[7] Multicollinearity is when two or more independent variables are highly correlated to each other.

1.6 Scientific Relevance

Even though the findings of this research will mainly be based on the results from the case study on ProActive, this research will provide a substantial basis for future research:

- This research demonstrates how a generic theoretical framework can be used to develop a concrete applicable model. More specifically, this case study shows the feasibility of a data driven quantitative modelling approach in a concrete business setting. In this way, this research demonstrates a method that software package suppliers can use to accurately predict their lead times and improve their SPI processes.
- In existing literature, plenty of research[8] can be found that investigates what the factors are that influence the implementation lead time in software package projects in general. However, little research has been performed on how these factors are applicable to the P2P-process, or how these factors can be used in a concrete business setting.
- By comparing the findings from previous works to the findings from the case study on ProActive, this research can be used to validate the findings from these previous works.
- By comparing the implementation process related to the findings from previous works to ProActive's implementation process, it can be assessed how the findings from this research can be applicable in other comparable implementation processes.

1.7 Thesis Structure

This thesis is further structured as follows. In chapter 2, the theoretical framework can be found. Hereafter, in chapter 3, the implementation process of the case study will be discussed and compared to the process that was found in the theoretical framework. Subsequently, in chapter 4, the data collection & preparation for this research will be discussed. Hereafter, in chapter 5, the analysis of data and the results for this research will be provided. Lastly, chapter 6 can be found, where conclusions will be drawn, recommendations will be provided, and suggestions for future work will be given based on the results of this research.

[8] This will be covered in the next chapter.

2 Theoretical Framework

The main purpose of this chapter is to provide an answer to the first sub-question: *"What approaches to the modelling of the process- and lead time distribution of P2P implementations and other SPI's can be found in previous literature?"*. Before going into the details of this SQ, a general introduction in the notion of process lead time and its determinants will be discussed in section 2.1.

2.1 Process Lead Time

Kenton (2020) defines the concept 'lead time' as "*the amount of time that passes from the start of a process until its conclusion*". Meyers et al (2012) describes the start of an implementation process as the moment an organization has officially decided to implement a desired product. The implementation process reaches its conclusion when the organization has fully incorporated the product into its organizational process(es) (Meyers et al, 2012).

On the basis of the above described definition of lead time, it can be said that, next to the waiting time, how the different activities between the start and conclusion of the implementation process are treated determines the eventual lead time. This means that in two different types of implementation processes[9] it is less likely that the same influencing factors are the most important in determining the eventual implementation lead time than in two similar implementation processes[10].

Waiting time is mainly a result of the process structure. For example, waiting time can occur when specific resources are required for an activity, but those specific resources are not available. In this case, the waiting time is the time it takes to get those resources available for that specific activity. If the process is structured in such a way that the required resources are available before the specific activity starts, no waiting time has to occur. However, if the sub-process of getting the required resources available initiates when the specific activity is ready to start, waiting time does occur.

2.2 Software Package Implementations & Influencing Factors

To find an answer to SQ 1, a literature search will be performed with the aim to find a model that describes the different steps of a SPI process (SQ 1a) and the factors that influence the lead time of a SPI process (SQ 1b). This section is thus structured as follows: firstly, the literature search will be described. Hereafter, a process model that was described in previous works will be explored. Hereby, important characteristics of this process model will be described, to get a better understanding of this specific kind of process. Lastly, several studies on important factors that influence implementation lead time in SPI's will be investigated.

2.2.1 Literature Search

The process models and influencing factors of implementation lead time in a SPI process were derived from the most relevant papers that could be found on Google Scholar and the Leiden University digital library. We first wanted to look for papers that studied the P2P implementation process, to see what we could learn from papers with a subject similar to

[9] When the different steps of the two processes are different to each other.

[10] When the different steps of the two processes are similar to each other.

this research (SQ 1). For this reason, we first used the search terms "*P2P Software Implementation", "P2P AND Software Implementation", "Purchase-to-Pay AND Software Implementation"* and "*Purchase-to-Pay Software Implementation"*. However, the search terms using the abbreviation "*P2P"* mainly returned papers on the subject of "*Peer-to-Peer-software"*, which is a completely different subject. Moreover, the other search terms mainly returned papers that researched how the performance of the P2P process could best be monitored, which is also not relevant to this research. On the basis of this, we concluded that we could not find a paper with a subject in the context of the P2P implementation process that we were looking for.

Next, it was decided to utilize a more generally applicable search term, because of the lack of studies on Purchase-to-Pay implementation process. Therefore, before looking for studies on important factors that influence implementation lead time, we searched for papers that modelled a more general SPI process. Hereby, it was decided to use the search terms *"Software Package Implementation AND Process Model" and "Software Package Implementation Model".* The first 10 works that the search engines returned for every different search term were analysed on relevance. These search terms mainly returned critical success factor (CSF) models for SPI, but there were two papers that had a main focus on the modelling of the SPI process: Lucas et al (1988) and Shin (1996).

Now that we found a SPI process model, we wanted to find studies on the most important factors that influence the implementation lead time of this modelled implementation process. Therefore, we searched for studies on the most important factors that influence the implementation lead time of SPI's in general. To find these studies, the search terms "*Software Package Implementation", "Packaged Software Implementation", "Software Package Implementation Factors", "Software Package Implementation AND Factors", "Software Package Implementation AND Lead Time",* and *"Software Package Implementation Lead Time"* were used. Also, the search terms "*Application Software Package Factors"* and "*ASP Implementation Factors"* were used, because the modelled implementation process was referred to as the "Application Software Package (ASP) Implementation Process". This will be further elaborated on in the next sub-section.

The search terms where the phrase *"Lead Time"* was included in mainly returned papers investigating supply chain lead time. Papers with a main focus on SPI lead time were not found with this search term. These papers were thus discarded.

The other search terms returned a collection of papers that mostly analysed how implementation success could be reached in the SPI process. The general consensus of most of these papers was that implementation success is determined by the time the implementation takes, the customer's satisfaction, and the financial costs of the project. The factors that were described in the papers on implementation success as influencing factors of the time the implementation takes were used for this research. The papers that did not consider implementation lead time were discarded.
Interesting to note was that most of these papers analysed the implementation success of Enterprise Resource Planning (ERP) software implementations. This type of software implementation is comparable to a P2P type of implementation, because ERP is essentially a software package solution that can be used for the automation of several different organizational processes, including the P2P process (SAP, 2020). However, this

also means that the P2P process is not always a part of an ERP implementation. Therefore, the papers that did not include the P2P process were also discarded.

This literature search resulted in 17 papers where research was performed where the topic of factors that could influence SPI lead time was covered, and 2 papers where a process model for SPI was developed, making it a total of 19 papers that were used for this theoretical framework. 13 of these papers were based on empirical research, and the other 6 papers mainly based their results on a literature survey. Only the factors from the different papers that showed to have an influence on the implementation lead time were used for this research. All 19 papers researched the influence of the factors on the complete implementation process. None of the 19 papers researched the impact of a specific factor on an activity level.

Table 1 & 2 on the next page provide an overview of these papers.

Table 1: Papers used for modelling the SPI process

Author	Year	Approach	Title
Shin et al	1996	Literature Survey	A process model of software package acquisition and implementation
Lucas et al	1986	Empirical Research	Implementing Packaged Software

Table 2: Papers used for finding important factors that influence SPI lead time

Author	Year	Approach	Title
Gerhardter et al	2013	Literature Survey	Flexibility and improved resource utilization through cloud based ERP systems: Critical success factors of SaaS solutions in SME.
Erazo et al	2013	Literature Survey	Analysis of software implementation process for ERP systems
Epizotone et al	2013	Literature Survey	Critical success factors for ERP system implementation to support financial functions
Frederiks et al	2005	Literature Survey	Information modelling: the process and the required competencies of its participants
Vaidya et al	2006	Literature Survey	Critical factors that influence e-procurement implementation success in the public sector
Hong	2002	Empirical Research	The critical success factors for ERP implementation: an organizational fit perspective
Umble et al	2003	Empirical Research	Enterprise resource planning: Implementation procedures and critical success factors
Fang et al	2005	Empirical Research	Critical success factors in ERP implementation
Ram et al	2013	Empirical Research	Implementation critical success factors (CSFs) for ERP: Do they contribute to implementation success and post-implementation performance?
Soja	2006	Empirical Research	Success factors in ERP systems implementations: Lessons from Practice
Chaturvedi et al	2011	Empirical Research	Software Package Implementation Sizing
Metrejean et al	2011	Empirical Research	The role of consultants in the implementation of enterprise resource planning systems
Petter	2008	Empirical Research	Managing User expectations on software projects: Lessons from the trenches
Parr et al	1999	Empirical Research	Identification of Necessary factors for successful implementation of ERP systems
Somers et al	2001	Empirical Research	The Impact of Critical Success Factors across the Stages of Enterprise Resource Planning Implementations
Holland et al	1999	Empirical Research	A critical success factor model for ERP Implementation.
Varadaraj	2012	Empirical Research	Successful software adoption - A study of software implementation methodologies

2.2.2 Modelling the Implementation Process

This sub-section will describe a model for a SPI process based on the papers that were found in sub-section 2.2.1. As the amount of selected papers shows, only a few accessible papers have actually modelled a process for SPI: Lucas et al (1988) and Shin (1996). Shin (1996) described his modelled process as the Application Software Package (ASP) implementation process: software developed by a third-party vendor that provides a general solution to some typical application problems. On the basis of fourteen different works on ASP acquisition and implementation, Shin (1996) developed a model of 25 steps an ASP implementation goes through. One of these fourteen different works is Lucas et al (1988). Therefore, it was decided to only use Shin's model (1996) for this research, because the model described by Lucas et al (1988) was already included in Shin's model (1996),.

Shin (1996) describes the ASP implementation process can be divided into three different phases:

- The first phase is the **Formulation Phase**. In this phase, activities are undertaken with the aim to set up a requirements list. This phase starts with setting up a project team and ends when the list of requirements is set up.
- The second phase is the **Selection & Acquisition Phase.** In this phase, a sufficient supplier for the ASP is acquired. This phase starts with collecting information about potential ASP vendors and setting up a request for proposal based on the list of requirements from the formulation phase. This phase ends with the signing of a contract with a vendor.
- The third and last phase is the **Installation & Post-Implementation Phase.** In this phase, the chosen ASP is implemented in the organization and evaluated. This phase starts with developing a planning for the implementation and ends with a performance evaluation.

Shin (1996) does not explicitly mention what the start- and end activities of the implementation process are. However, the official moment the customer has decided to implement the desired product is when the contract is signed. Also, the performance evaluation happens after the system is fully incorporated in the customer's organizational process(es). Therefore, based on what was learned from section 2.1, it is assumed the ASP implementation process starts when the contract is signed, and ends at the activity '*Performance Evaluation'*.

The order of the different events in this process is shown in figure 1, 2, and 3:

Figure 1: Formulation Phase in the Business Process Modelling Notation (BPMN)

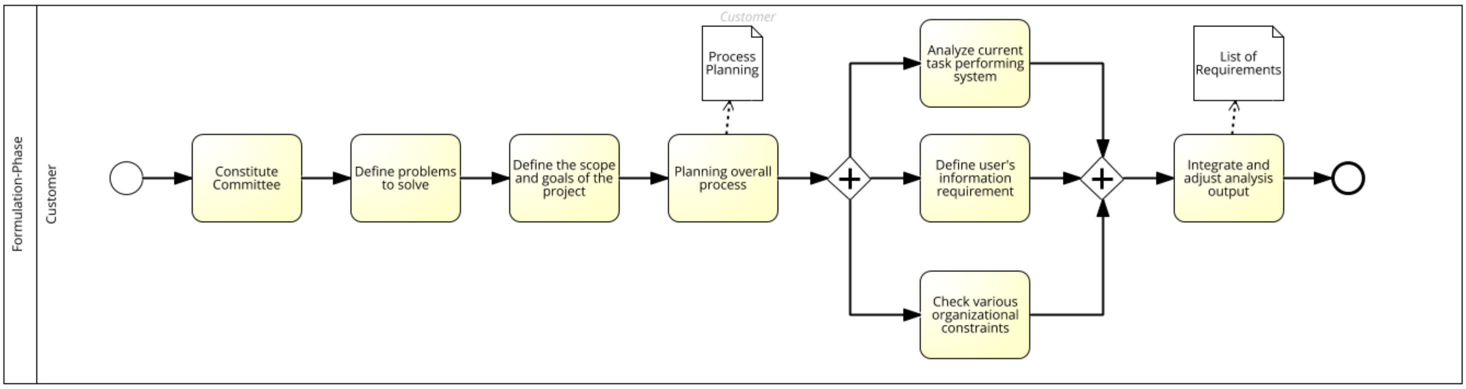


Figure 2: Selection & Acquisition Phase in BPMN

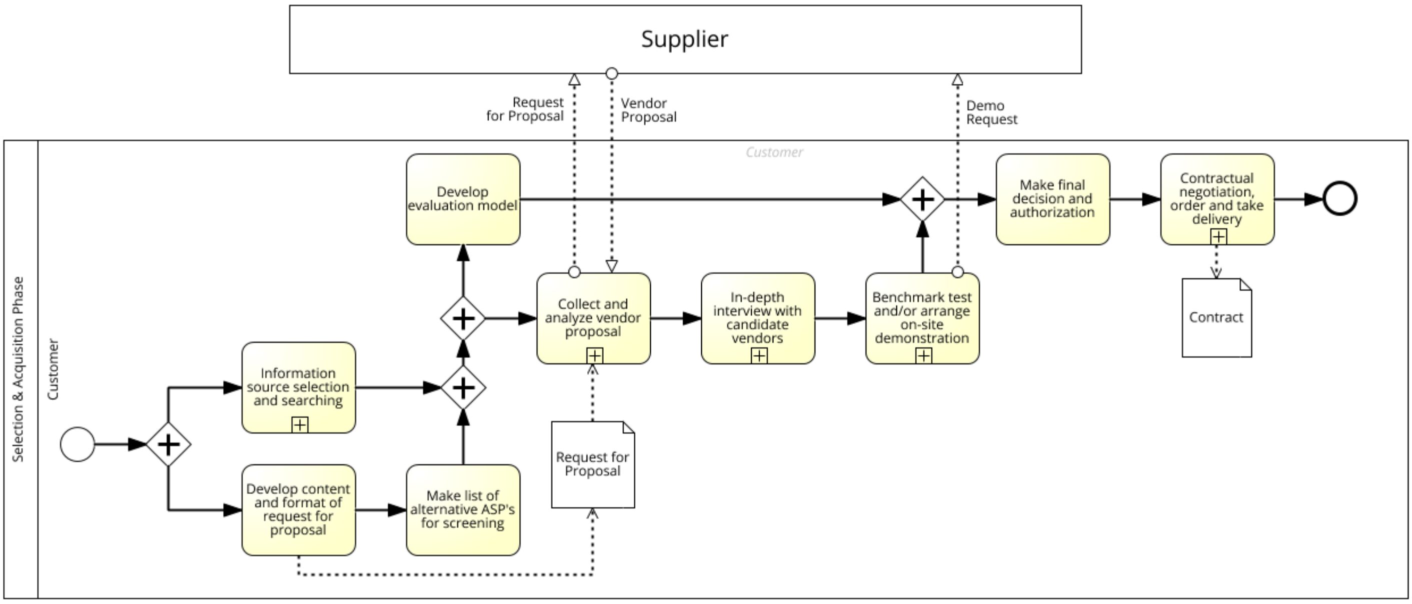
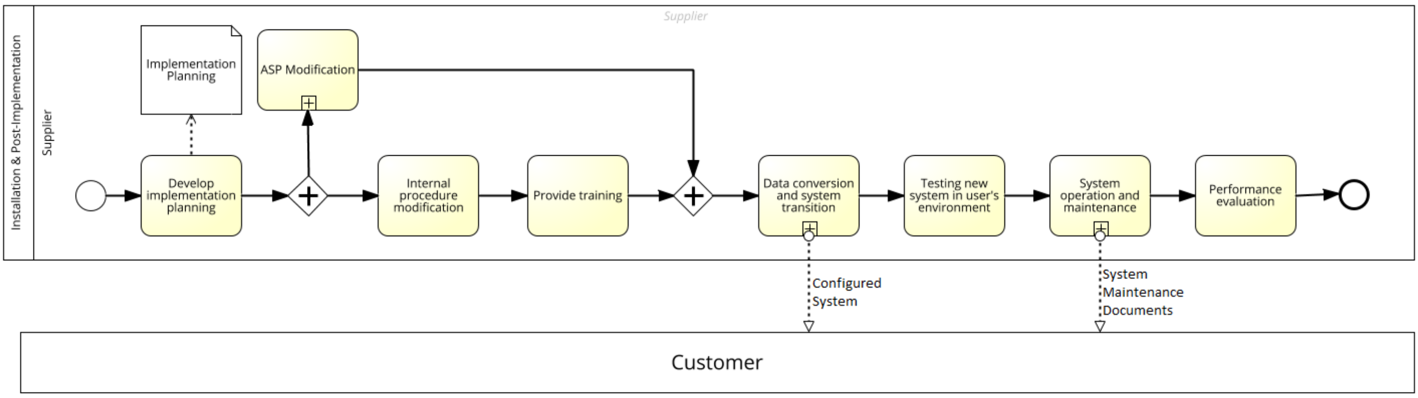


Figure 3: Installation & Post-Implementation Phase in BPMN



The first two phases of the modelled ASP implementation process are described from the customer’s perspective, while the third and last phase is described from the supplier’s perspective. This is the case because only the third phase describes the implementation process itself, which is the main part where the supplier is involved.

2.2.2.1 ASP Implementation Process Characteristics

In this sub-section, the characteristics of the ASP implementation process will be explored to get a better understanding of this specific type of process. Having a clear overview of the ASP process characteristics can be used to assess how these process characteristics are also applicable to other SPI processes. This also makes it possible to determine if the implications that follow from these process characteristics are also applicable to other SPI processes[11].

Software package solutions like an ASP generally have lower costs and shorter implementation lead times than customized implementations, because the development of the standard software package is done apart from the implementation process (Lucas et al, 2014). Customization in ASP implementations is generally only done when the type of customization is relevant for multiple clients (Mortensen et al, 2017). The reason for this is, when the customization turns out not to be applicable for multiple customers, the customization will simply not be profitable for the ASP supplier. The added value of customization for a single customer is often overrated, because most of the time it does not weigh up against the related costs (Mortensen et al, 2017). On the other hand, Piller (2004) states that customers gain from customization because they receive a product that fits their requirements better than the best standard product available. If this customization is useful for multiple (potential) customers, this customization helps in achieving a competitive advantage (Piller, 2004). The reason for this is that in such case the specific customization can be reused in "better addressing the customer's requirements than the best standard product available", without having to put in as much effort in the customization as the first time it was created (Piller, 2004). Therefore, when a customer wishes for a customization in an ASP implementation project, this wish should only be granted if the supplier thinks the customization may be applicable to multiple customers and will be profitable in the long term (Goldsmith, 1985).

The '*ASP Modification'* step in figure 3 only consists of configuring the standard software package based on the customer's requirements. In a custom developed software implementation on the other hand, some sort of "*change request"* step always exists, where the customer can request the supplier for new features or bug fixes (Kagdi et al, 2009). This means the supplier is not limited to the standard configuration possibilities of the software package in a customized implementation process. Therefore, the supplier is way more flexible in a custom developed software implementation than in an ASP implementation.

Research by Saenz (2018) has shown that manufacturing flexibility positively correlates with customer satisfaction. Saenz (2018) defines 'Manufacturing flexibility' as follows: "*the ability of an organization to adapt its products to varying customer wishes"*. Making changes to a product with a lower level of flexibility is more difficult than making changes to a product with a higher level of flexibility. This also means that a higher

[11] For example, if one of the ASP process characteristics would be that it is less flexible than other types of implementation processes because an ASP implementation has no room for customization, this is probably also the case for other SPI processes where the possibilities for customization are limited.

level of manufacturing flexibility makes it easier to meet the customer's wishes without facing excessive delays or quality decrease[12] (Saenz, 2018). However, a lower level of manufacturing flexibility increases the chance of facing delays or decreased product quality when trying to meet the customer's wishes as it will be more difficult to adapt to these wishes when changes are required in order to meet the customer's expectations.

Furthermore, because the ASP implementation is generally perceived as easier to do than a customized implementation, customers tend to put less effort in these type of implementations (Light, 2005). This sometimes results in these customers providing too little effort, which negatively affects the implementation success[13] (Iivari, 1990). Also, because customers tend to think lightly about an ASP implementation, the decision to implement an ASP is quicker made than the decision to implement customized software. Because of this, the customer tends to put less effort in preparing their requirements for an ASP implementation, compared to how the customer would prepare for a customized implementation. This results in more uncertainties about the user's requirements and also more uncertainties about if the ASP solution is able to meet those requirements (Ngwenyama et al, 1999). These uncertainties are further exacerbated in the acquisition process: Ngwenyama's research (1999) has also shown that buyers of an ASP have the tendency to choose their supplier based on the vendor's salesmanship, rather than on the product quality. This could result in the customer finding out later in the process that not all important requirements can be met. Because of the lower flexibility, in such a case the system often cannot fully be adjusted to the user's demands, resulting in lower implementation success.

2.2.3 Modelling Software Lead Time Distribution

This sub-section will describe the most important factors that influence SPI lead time, based on the literary works that were found in sub-section 2.2.1. First, these different literary works will be described and analysed: to get an idea how the different important factors emerged from the seventeen different studies, the main goal and approach of these studies are briefly described. Hereafter, all the different factors that came forward out of these seventeen studies as important will be briefly described. Following up on this, the results from these studies are summarized in table 3. This table provides an overview of what factors these studies deem to be the most important factors, and what other factors came forward out of these studies as important. Based on what factors come forward out of these studies as most important most frequently, the top five most important factors that influence the implementation lead time of a SPI process will be described. Lastly, it will be described how the different important factors could impact each other.

[12] Software Quality is the existence of characteristics of a product which can be assigned to requirements (Petrasch, 1999). Facing quality decrease to meet customer expectations means sacrificing some of these product characteristics to meet other specific customer expectations.

[13] Implementation Success: Implementation Lead Time, Customer Satisfaction, Financial Costs.

2.2.3.1 Important Factors that Influence SPI Lead Time

As mentioned earlier, "software implementation lead time" is not a commonly used term in existing literature. Relevant previous works mostly focus on how to reach 'implementation success'. Hereby, the most important elements in reaching this implementation success often include 'schedule', or 'meeting deadlines'. As these terms mainly consist of reaching the goals of the implementation within a predetermined period of time, these elements are well comparable to 'implementation lead time', which is why these studies were useful for this research.
For all analysed papers it was checked if the research results were based on empirical research, or on other literature. Next to this, it was also determined if a factor can only be influenced by the customer, if both the supplier and the customer influence on a factor, or if the supplier has complete control over how a factor gets influenced.

Papers based on Literature Survey

- Gerhardter et al (2013) performed a study on the changes of Critical Success Factors (CSF's) in cloud based ERP systems because of product innovation. For this study, Gerhardter et al (2013) performed a literature survey to define the most important CSF's of an ERP package software implementation. Hereby, Gerhardter et al (2013) mentions meeting CSF's leads to a lower 'implementation time'.
- Erazo et al (2013) performed a literature search study with the aim to define the ERP implementation process and the related success factors. Hereby, Erazo et al (2013) describes that meeting these related success factors helps realizing an implementation within a limited period of time.
- Epizotone et al (2013) looked at CSF's for the implementation of ERP systems that support financial systems. They looked at 127 different studies and derived 205 different factors from those studies. Based on the median statistics from those studies, the top six most important factors that influence ERP implementations were derived. Hereby, it is mentioned that dealing with these factors in a sufficient way leads to a lower 'implementation life cycle time', compared to when these factors are not dealt with.
- Frederiks et al (2005) performed research on the required competencies for a customer in a SPI process. Based on literature search, the top five required competencies were formulated. Hereby, it is described that the presence of these competencies in a customer lead to a shorter 'implementation completion time', compared to when a customer does not have these competencies.
- Vaidya et al (2006) performed literature research on the CSF's for E-procurement package implementations. Hereby, it is described that dealing with these CSF's in a sufficient way increases the chance of finishing the implementation 'on-time', compared to when these CSF's are not dealt with.

Papers Based on Empirical Research

- Hong (2002) performed a case study on why ERP implementations generally do not meet their deadlines from an organizational fit perspective.

- Umble et al (2003) performed research of success factors, software selection steps, and implementation procedures critical to a successful SPI. A case study was performed on a perceived as largely successful implementation. Hereby, it is described that a successful SPI demands less ‘corporate time’ than a less successful SPI.
- Fang et al (2005) performed a case study on six different ERP suppliers with the aim to derive the most important factors that influence the success of the implementation process. Hereby, it is described one of the main predictors of success is ‘meeting the project schedule’.
- Ram et al (2013) tested if CSF’s that are widely supported in existing literature as important always influence the outcome of a SPI by testing the four most important CSF’s derived from previous work in a case study environment. In this study, it is described an implementation is perceived as successful when it goes live within budget and ‘schedule’, and with agreed upon requirements.
- Soja (2006) performed an empirical study among practitioners that regularly deal with ERP implementations with the aim to find the most important factors that influence SPI’s. The practitioners were asked to rate the impact of different factors on a one to five Likert-scale. The impact of the different factors on the implementation success was the quantified in this study by averaging the respondents answers and testing the significance of these averaged answers. ‘Duration time’ is hereby described as one of the most important predictors of implementation success.
- Chatuverdi et al (2011) designed an empirical framework for the impact of implementation sizing on implementation lead time. This study was performed because he found project management as the most important factor that influences implementation success and lead time. Chaturvedi et al (2011) followed up on this finding by investigating the impact of implementation size on the factor project management.
- Metrejean et al (2011) used survey methods to analyse the impact of the supplier’s level of assistance on the eventual implementation success. ‘Implementation time’ is hereby described as one of the most important predictors of success.
- Petter (2008) interviewed several managers that deal with SPI’s to examine the influence of customer expectations on implementation success. This study followed up on the finding from previous studies that the customer’s expectations are one of the most important factors in determining implementation success and lead time.
- Parr et al (1999) interviewed several ERP consultancy managers to set up a list of the most important factors that influence ERP package implementation success. Parr et al (1999) describes meeting deadlines is one of the most important elements of implementation success.
- Somers et al (2001) sent out surveys to 86 different companies and averaged the results of the surveys to measure the impact of the CSF’s of ERP package implementations throughout the different stages of the implementation process. The respondents were asked to rank the top five most important factors that influence lead time. A percentage score was then assigned to the different factors, based on how often a specific factor was mentioned in a respondent’s top five and with what rank. Somers et al (2001) describes dealing with the most important CSF’s is crucial to avoid ‘schedule overruns’.

- Holland et al (1999) performed a case study on the most important factors that influence the implementation success of SPI's in general. Interviews were held with employees from eight different ERP software suppliers to derive the most important factors. 'Project schedule' is hereby described as one of the most important elements of implementation success.
- Varadaraj (2012) sent out several surveys to software package vendors to find out what those vendors think are the most important factors that should be taken into account to reach successful software adoption. Hereby, software adoption time is described as one of the most important aspects of a successful software adoption.

In all the above mentioned papers, the concept "implementation lead time" is not specifically defined with a start- and end activity. Therefore, as was also the case in sub-section 2.2.2, it is assumed the implementation process starts when the contract is signed, and ends with a performance evaluation activity.
The factors that came forward out of these studies as important influencing factors of implementation lead time are the following:

Factors the customers have to handle by themselves:

1. *Customer Requirement Preparation.* When the customer does not exactly know what he wants to get out of the implementation, the chance is higher that not all customer requirements will be met, compared to when the customer has a well-designed list of requirements. This increases the chance customization will be required to still be able to meet the customer's requirements later in the process, which could lead to a longer lead time.
2. *Top Management Support / Commitment to the Project.* Epizotone et al (2019) describes "*top management support / commitment*" is mainly important because the customer's top management has to do the authorizing, commissioning, and allocation of resources for the project. A low level of commitment to the project for example could lead to not having the required resources available for the project compared to when the level of commitment would be high. This would lead to a higher lead time.
3. *Customer's Skills / Experience with Similar Implementations*. A project is significantly easier to execute when the participating stakeholders are experts on the topic of the project, compared to when the same project is held with stakeholders that do such a project for the first time. Having to do a project with less capable people means more time is required to make the project a success[14] (Fang et al, 2005).

Factors that are the customer's responsibility where the supplier can help with:

4. *Project Management / Planning Monitoring*. Gerhardter et al (2013) describes having a clear project planning and a project manager with the right skill set to manage the project significantly improves the efficiency of the project group, which often results in a lower lead time.
5. *User Adaptability. "If the employees do not understand how a system works, they will invent their own processes using those parts of the system they are able to manipulate"* (Umble et al, 2003). User adaptability can be defined as the time it

[14] For example, because a less capable user needs more time to adapt to a new way of working than a skilled and experienced user.

takes for a user to sufficiently change to a new way of working (Umble et al, 2003). A higher user adaptability thus means a user is quicker to adapt to a new way of working compared to a user with a lower user adaptability, which leads to a lower implementation lead time.

6. *Customization.* As was also mentioned in sub-section 2.2.3, SPI's have a low level of manufacturing flexibility, which means customization could significantly increase the implementation lead time of a SPI project (Mortensen et al, 2017).
7. *Resource Allocation.* Having the right resources and competencies in the right places positively influences the efficiency and effectiveness of the implementation process and leads to lower lead times compared to when required resources and competencies are not sufficiently allocated (Frederiks et al, 2005).
8. *Organizational Fit of the System.* Hong (2002) showed a system that easily fits into an organization and its existing processes often has more support from its users compared to a system that does not adapt well to the current organizational processes. The less support the project has, the less interested users are to participate in the project, which often results in the project getting delayed multiple times (Hong, 2002).
    a. *Product Quality.* The acceptance of a software system is higher when the system is easy to use, and resistance will go away more quickly when it is easy to show that the system is an improvement for the organization (Ram et al, 2013). Also, with a higher product quality, less customization should be required to make the system fit into the customer organization, compared to with a lower product quality.

Factors that the supplier has complete control over:

9. *Implementation Size (Estimation).* Not being able to accurately estimate the size of a SPI can result in significant higher lead time and costs, for example because it makes it more difficult to set up an efficient project planning (Chaturvedi et al, 2011). Also, Chaturvedi et al (2011) states that a SPI with a bigger size requires more work compared to a SPI with a smaller size[15].
10. *Consultant's Level of Assistance.* If the consultant makes an unforced error, or just does not provide the guidance that the customer needs, the project lead time will increase (Epizotone et al, 2019).
11. *User Training and Education.* Gerhardter et al (2013) and Umble et al (2003) describe user training and education as essential for the user to adapt to the new way of working as quickly as possible.
12. *Clear Division of Roles in the Project.* According to (Erazo et al, 2017), one of the most important things to have for a quick SPI is having a clear division of individual tasks between all different stakeholders, to make sure everyone has a clear image of what they have to do. This clear image should enable everyone to allocate their resources and competencies as effectively as possible, which leads to a lower lead time compared to when these resources are not sufficiently allocated (Erazo et al, 2017).
13. *Customer Expectations about the product's functionality or about the division of roles in the project and the prerequisites to efficiently fulfil those roles.* Next to the

[15] Chaturvedi et al (2011) states that the size of a software package implementation is determined by three different aspects of the implementation: the amount of specific tasks that are required to complete the implementation, the size of these tasks, and the 'complexity factor': the more complex the tasks are, the longer it will take to complete those tasks.

importance of a clear division of roles, as mentioned in sub-section 2.3.3, not meeting the customer's expectations about the product's functionality could lead to having to make changes to the product later in the process (Saenz, 2018). This is harder to do for software package suppliers because of the lower product flexibility, and therefore leads to a longer lead time (Saenz, 2018). This factor will further be referred to as '*Customer Expectations*'.

a. *Availability of Prototype.* Petter (2008) describes customer expectations cannot be accurately shaped without the availability of a prototype.

Table 3 provides an overview of how the 17 different papers rate the importance of the different factors.

*Table 3: Different papers defining the most important factors that influence implementation lead time in SPI projects. 'X' shows that the specific paper rates the factor as important. A green '**X**' shows that the specific paper rates that factor as most important.*

Author	Year	1: Req. Prep	2: Top Man. Supp / Cust. Com.	3: Cust. Skills	4: Proj. Man. /Plan.	5: User Adapt.	6: Custom.	7: Res. All.	7a: Prod. Qual.	8: Org. Fit	9: Impl. Size Est.	10: Cons. Assist	11: User Train. & Edu.	12: Divis. Of Roles	13: Cust. Expec.	13a: Proto-type
Gerhardter et al	2013	-	**X**	X	X	-	X	X	X	X	-	X	X	-	-	-
Umble et al	2003	-	**X**	-	**X**	-	-	-	-	-	X	-	X	-	-	-
Erazo et al	2013	-	-	X	-	X	-	X	X	X	-	-	-	-	-	-
Fang et al	2005	-	**X**	X	**X**	X	X	X	-	X	-	X	X	X	-	-
Epizotone et al	2013	X	**X**	X	X	X	X	X	X	X	X	X	-	X	X	-
Hong et al	2002	X	-	-	-	X	**X**	**X**	X	**X**	-	-	X	-	-	-
Ram et al	2013	X	**X**	X	**X**	X	X	X	X	X	-	X	X	X	X	-
Petter	2008	-	-	-	X	-	-	X	-	-	-	X	-	X	**X**	X
Parr et al	1999	X	**X**	X	**X**	X	-	-	-	-	-	-	X	-	-	-
Somers et al	2001	X	**X**	X	X	X	X	X	-	-	-	X	X	-	**X**	-
Frederiks et al	2005	-	-	-	-	-	**X**	**X**	-	-	-	-	-	X	**X**	-
Soja	2006	X	**X**	X	X	-	X	X	-	-	X	X	X	X	X	-
Vaidya et al	2006	X	**X**	X	-	X	**X**	X	X	X	-	X	-	-	**X**	-
Chaturvedi	2011	X	-	-	**X**	-	X	X	X	-	X	X	-	X	X	-
Metrejean et al	2011	-	-	-	X	X	X	X	X	X	-	X	-	X	**X**	-
Varadaraj	2012	-	**X**	-	**X**	X	-	X	-	-	-	-	-	-	**X**	-
Holland	1999	X	**X**	X	**X**	-	-	X	-	-	-	X	X	X	**X**	-
	Amount of Total X,X	9,0	11,11	9,0	12,6	10,0	11,3	15,2	8,0	8,1	4,0	11,0	9,0	9,0	11,7	1,0

Table 3 shows what the different papers rate as the most important factors that influence SPI lead time. Based on how often a factor gets rated as the most important factor, the top five of the most important factors is as follows:

1. Top Management Support / Customer Commitment
2. Customer Expectations

3. Project Management / Planning
4. Customization
5. Resource Allocation

The investigated literature mainly based their results on interview- or survey results. Also, some papers had the focus on investigating the impact of one specific factor in the context of a case study[16]. Only the studies by Somers et al (2011) and Soja (2006) quantified the impact of the different factors on the implementation lead time, both on the basis of survey responses. The main difference between this top five and the top five factors described by Somers et al (2001) and Soja (2006) is that the factor '*Customer Skills'* is ranked as one of the top five most important factors in both studies. Other than that, the results from Somers et al (2011) and Soja (2006) are in line with the above described top five.

2.2.3.2 Interdependencies between Different Factors

This sub-section describes how the used papers indicate the different factors impact each other.

Somers et al (2001), Metrejean et al (2011), Varadaraj et al (2013), Frederiks (2005), Petter (2008), Holland et al (1999) and Vaidya et al (2003) all mainly underline the importance of the factor '*customer expectations*', because this factor influences several other factors:

- In order to minimize implementation lead time, it is critical to allocate necessary resources where they are required for effective usage of time (Rushton et al, 2010). To be able to do so, it is important that it is clear to all stakeholders involved what resources and what competencies are required from every different side, and where they should be used (Vaidya et al, 2006). Therefore, it is important for a supplier to proactively inform the customer about what their exact role in the project is, what they can expect from the supplier's side, and where to pay attention to in the project, to aid the customer in efficiently allocating their resources and acquire and efficiently utilize their required competencies[17] (Vaidya et al, 2006).
- The better a customer's expectations are in line with what the software system can offer, the less unexpected changes have to be made later in the project, and the less customization will be necessary later in the project in able to meet these customer expectations.
- If a customer is less experienced with similar implementation projects, preparing the customer on how to most efficiently conduct their role in the project minimizes the risk of suffering from delays because of this lack of experience.

Ram et al (2013), Parr et al (1999) and Somers et al (2001) underline the importance of the customer's employees skills and experience with similar implementations. They describe that next to this factor, training & education and the consultant's level of assistance are mainly important because they increase the level of user adaptability. Shin

[16] Such as Chaturvedi et al (2011) on the factor 'implementation size', or Hong (2002) on 'organizational fit'.
[17] For example: when a supplier makes clear they will not manage the project for the customer organization, but that a project manager with the right skill set is necessary in achieving implementation success, it will be easier for a customer to anticipate on this.

(1996) and Ram et al (2002) also describe this user adaptability is influenced by how well the customer prepares his requirements, because this helps in choosing a supplier that best fits with the customer organization. In this way, user adaptability also positively impacts the organizational fit (Ram et al, 2013). This is advantageous, because a better organizational fit should decrease the amount of required customization (Hong, 2002).

Furthermore, the factor '*Project Management / Planning'* often comes forward as a factor that correlates with several other factors. For example, Umble et al (2013), Ram et al (2013), Fang et al (2005), and Parr et al (1999) describe it is easier to sufficiently manage a project when the top management is fully supporting the project and the customer is generally committed to the project. Also, when the customer's expectations about the required division of roles are in line with the supplier's reality, it is more likely a project will be sufficiently managed (Reich et al, 2010). For example, when a customer organization knows they have to manage the project by themselves, but they have no internal employee available with the right skill-set to successfully manage a specific project, most of the time they decide to hire an external project manager that is more experienced with similar projects (Reich et al, 2010). Reich et al (2010) states that hiring this external project manager makes the risk of not being able to manage the project properly remarkably smaller, which saves a significant amount of lead time. This indicates that when the customer is aware of their role in the project and what the resources and competencies are that are required for their role in the project (in the previous example the required skill-set of the project manager), the risk of the implementation suffering from delays is narrowed down because it enables them to take action on their shortcomings. This is also supported by Frederiks (2005).
Lastly, a project with a bigger size[18] is more difficult to manage compared to a lower sized project (Sauer et al, 2007).

2.3 Conclusion

In this chapter, SQ 1 was answered by finding an answer to both SQ 1a and SQ 1b. SQ 1a was answered by modelling a SPI process in sub-section 2.2.2. SQ 1b was answered by deriving the most important factors that influence SPI lead time from 17 different papers in sub-section 2.2.3. The relative impact of the different factors, the interdependencies between the different factors, and the supplier's influence on the different factors are all summarized in the *literature model* on the next page (Figure 4 & 5). Figure 4 provides an overview of the factors that directly impact the implementation lead time, and figure 5 shows the interdependencies between the different independent variables. The impact of the different factors is indicated by the size of the arrows: a bigger arrow is a bigger influence than a smaller arrow. For example, the division of roles in a project and the efficient allocation of resources are both very much influenced by how the customer expects that the supplier has this in mind, and if the resources are not allocated efficiently the project management factor will suffer from this. The implementation size estimation on the other hand also has an influence on the project management factor, but is not as big of an influence as the 'division of roles' and 'resource allocation' factors.
The different colours show if the supplier can influence a specific factor completely, partially, or not at all. For example, the supplier is in complete control of the consultant's

[18] More complexity / More Activities / Longer Activities.

level of assistance, but cannot influence how the customer prepares for the implementation, which means the user's adaptability is partially influenced by the supplier. Lastly, a "+" indicates a positive correlation between two factors, and a "-" indicates a negative correlation between two factors.

Figure 4: Factors that directly impact the implementation lead time

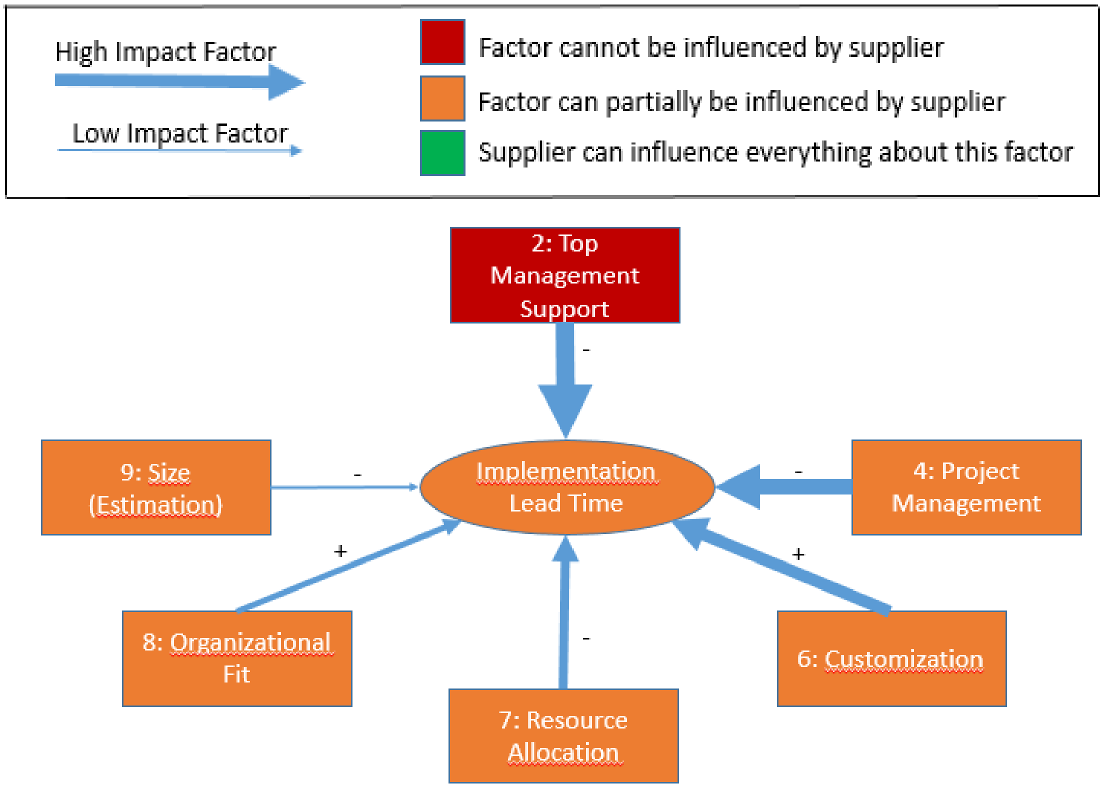
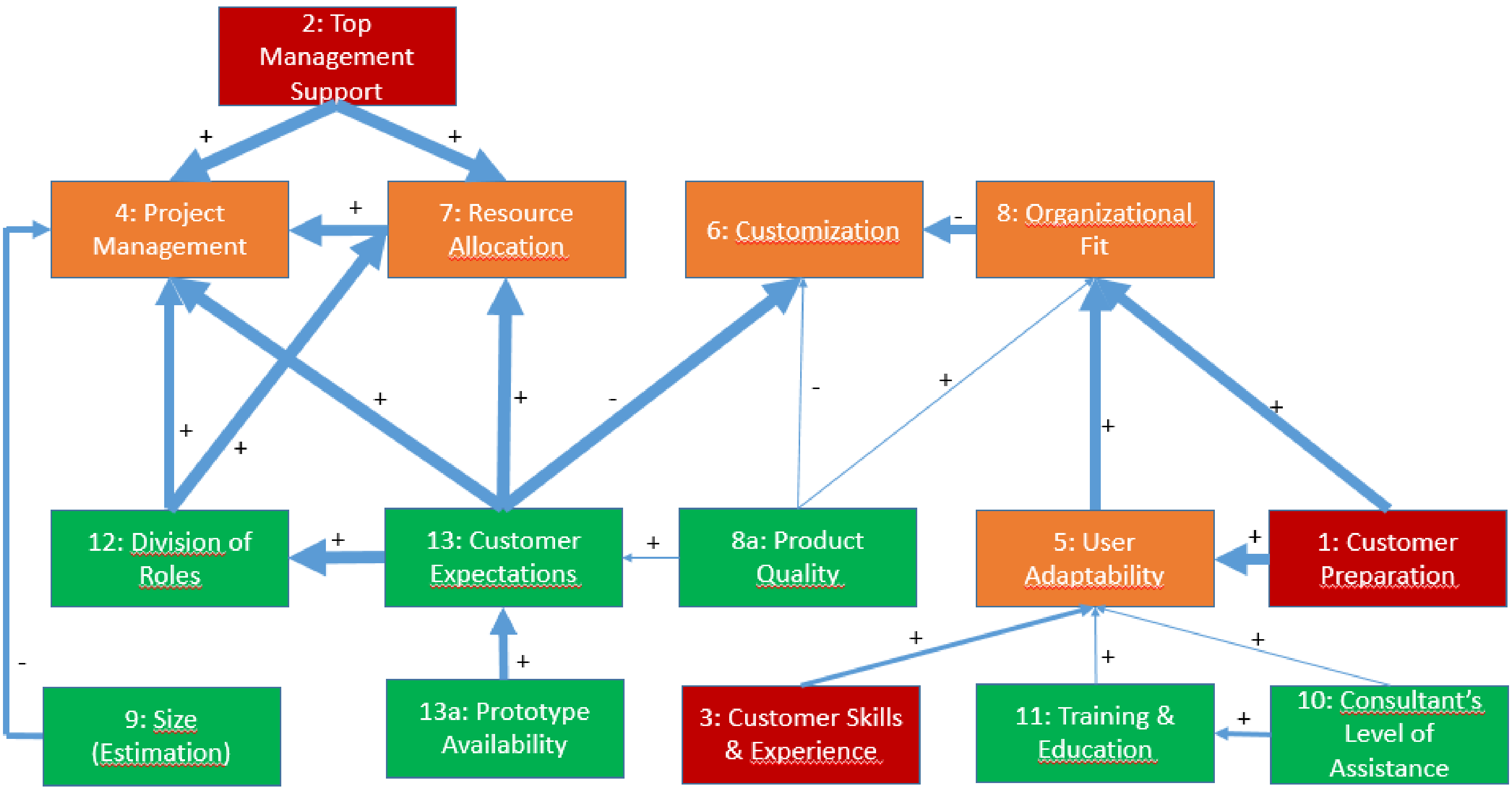


Figure 5: Interdependencies between the different factors.



Nevertheless, there are some limitations to this theoretical framework. In this study, the main goal is to quantify the impact of the most important factors on SPI lead time. However, the above mentioned findings are rather qualitative[19]: most of the 17 papers that we used to derive the most important factors from used qualitative approaches[20] for their studies, while we want to quantify the impact of the different factors by using empirical data.
Also, important to note is that not everything that we wanted to find could be found in literature. For example, we could not find a paper that specifically focussed on purchase-to-pay implementations.
Next to this, the process model from sub-section 2.2.2 mainly describes the process from the customer's perspective, whereas in this study the implementation process is mainly analysed from the supplier's perspective. This means the part of the ASP implementation process where the supplier is not involved in cannot be used for this study.
Moreover, we wanted to find studies that describe the impact of the different factors that influence lead time on an activity level, because a process' lead time is caused by the time the activities in the process take and the waiting time that is caused by the process' structure. However, the factors from the different studies were not described on an activity level.
Lastly, interesting to note was that a substantial amount of the relevant studies on SPI's were on ERP software implementations. Whereas ERP implementations and P2P implementations do have some overlap, ERP software generally covers more organizational processes than only the P2P process (SAP, 2020). This means ERP implementations are generally larger in size than P2P implementations.

[19] Only two out of seventeen papers developed a quantitative model. The two papers that did develop a quantitative model only quantified survey responses, whereas the aim of this study is to quantify the impact of the different factors with empirical data.
[20] Most papers mainly based their results on interview- and survey responses.

3 Case Study: P2P Package Implementation at ProActive

In the previous chapter, we investigated existing approaches to the modelling of the ASP implementation process. This chapter will follow up on the previous chapter by modelling and analysing ProActive's implementation process. The purpose of this chapter is to first of all determine whether the observations from the case study confirm the implications from the theoretical framework. Hereby, ProActive's implementation process is investigated and compared to the process model from the theoretical framework (SQ 2). Also, the project administration is investigated, because it is a potential source of empirical data for further validating the theoretical framework and later creating the quantitative model.

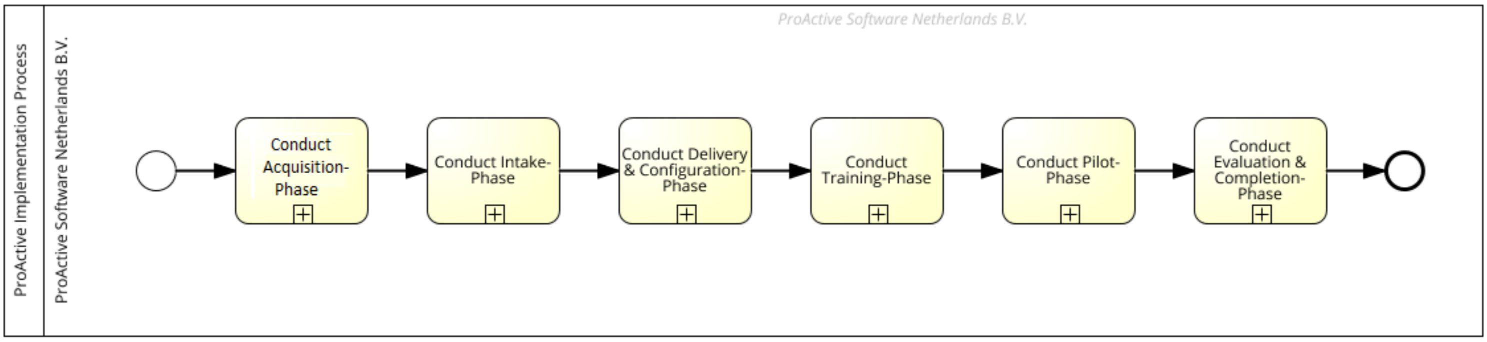
3.1 ProActive's Implementation Process

In this section, an overview of ProActive's implementation process will be provided by modelling its different phases. A step-wise approach was used for the modelling of this process and its different phases. This approach was based on the different steps in a modelling process described by Winston et al (2012):

1. Firstly, data was collected to understand what happens in the different steps of the implementation process, which was necessary in the later development of the process models. In ProActive's documentation, only a general description of the different steps of their implementation process could be found. This did not provide enough data to model the different phases of the process with. Therefore, a consultant from ProActive was interviewed and asked to provide a detailed explanation of the different steps in the implementation process.
2. The transcription of the interview was then used to develop the process models of the different phases.
3. The next step was to ensure the validity of our process models. This was done by asking two other consultants if the models were an accurate representation of the reality.
4. On the basis of the feedback from the two other consultants, the models were adjusted and again validated by the two other consultants.
5. When the two other consultants stated that the models were a perfect representation of the reality, the modelling process was ended.

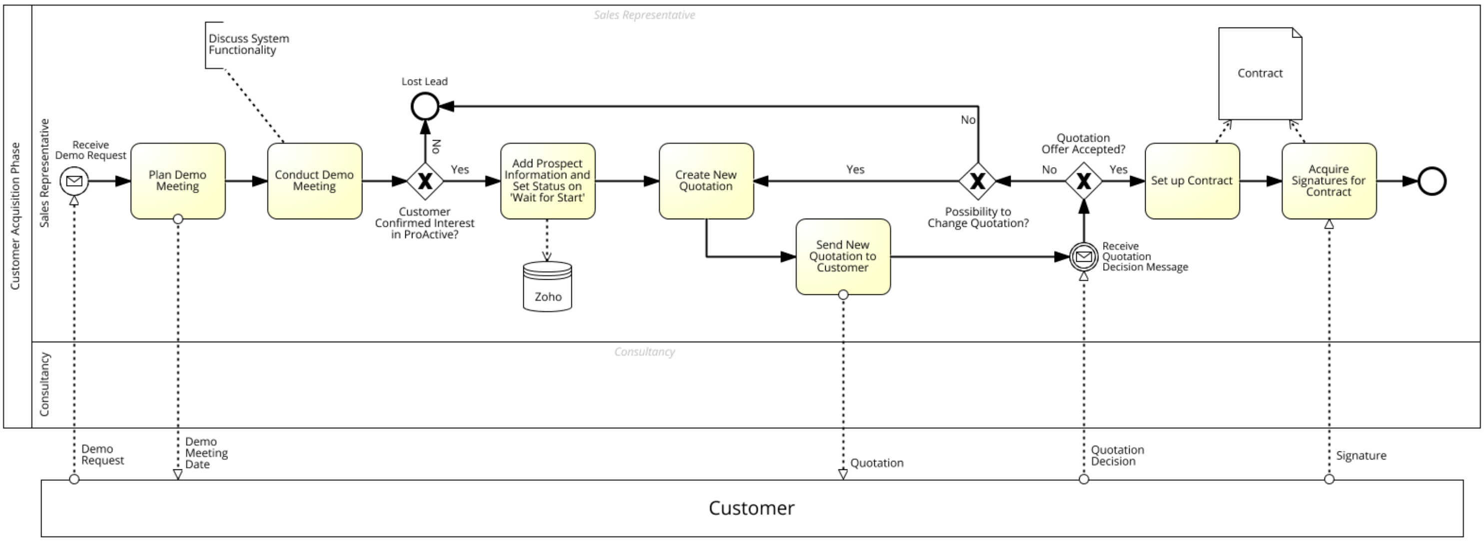
A global overview of the different phases in ProActive's implementation process is shown in Figure 6.

Figure 6: Global overview of ProActive's Implementation Process



As figure 6 shows, ProActive distinguishes their process in six different phases: the 'acquisition-phase', the 'intake-phase', the 'delivery & configuration-phase', the 'training-phase', the 'pilot-phase' and the 'Evaluation and Completion-phase' (Figure 7, 8, 9, 10, 11 & 12). The remainder of this section will describe what happens in the different phases, and how each phase contributes to the implementation lead time. A more detailed explanation of the activities of each phase can be found in Appendix VI.

Figure 7: Acquisition-Phase.



The acquisition-phase is not a part of ProActive's implementation process itself. However, this phase will still be analysed, because this is the phase where ProActive comes in contact with the customer for the first time. Therefore, the customer can already be influenced in this phase, which can have an effect on how the customer acts in the eventual implementation process. For this reason, the acquisition-phase is also relevant to this research.

In the acquisition-phase, the main goal of the account-manager[21] is to turn a prospect[22] into a customer. The demo meeting[23] is the main point in the process where the sales representative has to convince the prospect to go for ProActive. At the same time, the main goal of the prospect is to find a sufficient supplier with a software solution that is suitable for the problems they want to solve. The customer's

[21] The account-manager is the sales representative from ProActive.

[22] Prospect: Potential Customer

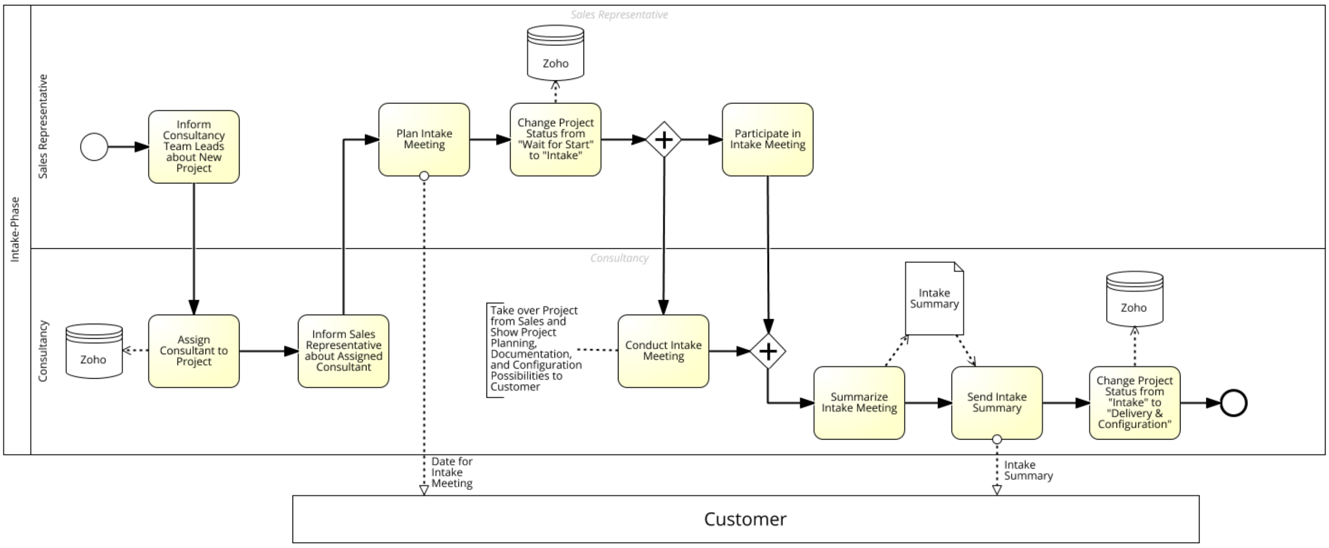
[23] The demo meeting is also referred to as 'Introductory Meeting' or 'Sales Demo'.

decision is almost always made on the basis of the sales demo. After the customer decides to go for a certain supplier, the terms of the contract are negotiated and after all important stakeholders have signed the contract, the acquisition-phase ends and the intake-phase starts.

To be able to observe how the customer is being influenced in the acquisition-phase, one sales demo was joined. This particular sales demo was divided into three sessions of one hour each. Shortly after the specific sales demo-sessions, the related account manager was interviewed to get a better view of how sales demos are generally structured.

It was observed in these sales demo sessions that the main goal of the account-manager is to get the customer to go for ProActive. What the account manager tells the customer in able to achieve this goal is different for every different customer. According to the interviewed account manager, this sometimes results in a mismatch in what the customer expects from ProActive and what ProActive actually offers, which could lead to a delay in implementation lead time. This implies that the factors that influence the implementation lead time, and mainly the customer's expectations, can already be influenced in the first phase(s) of a project.

Figure 8: Intake-Phase.

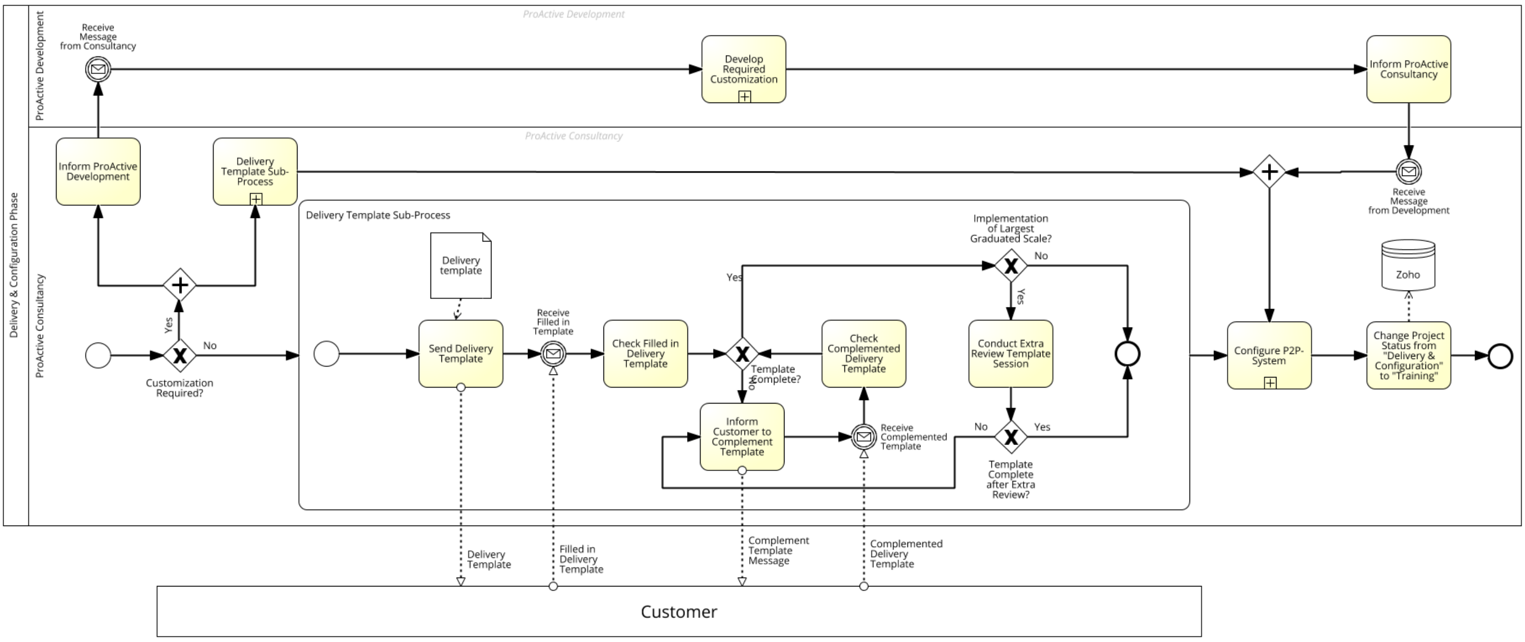


After the acquisition-phase, ProActive's account-manager transfers the project to one of the consultancy team-leads, and the assigned team lead then assigns the project to a consultant based on the consultant's affinity with the type of customer (industry, personality, etc.) and time leftover in the consultant's schedule. The official transfer from sales to consultancy happens at the end of the intake-meeting. After the meeting, a summary of the intake is drawn up and sent to the customer by the consultant, which is the end of the intake-phase.

The main goal of the intake is to manage the customer's expectations about the product and their role in the implementation process as good as possible by showing the different configuration possibilities, the available documentation, and by providing the customer with a rough planning.

The main steps in the process where ProActive can prepare the customer for the implementation process are the sales demo and the intake meeting, because those are the only two steps before the implementation process has started where ProActive is involved in. If the customer is convinced to make a deal, ProActive has until the end of the intake to prepare the customer for the implementation process. After the intake, the ‘delivery & configuration’-process starts, where the product is configured in an attempt to meet the customer’s requirements.

Figure 9: Delivery & Configuration-Phase



Before the consultant can start the configuration of the system, the customer first has to fill in the delivery template. This template contains information about for example the organizational structure of the customer with the related roles and job-functions. This information enables the consultant to assign rights in the system to the right people within the customer’s organization. If the customer ordered a module of the largest size, the delivery template is checked one extra time in a “review template-session” with both the consultant and the customer.

Also, when customization is required for the project[24], the consultant has to wait with the configuration of the system until the development department has realized the required customization. If customization is not required, the consultant can start the configuration of the system after the ‘delivery template sub-process’ ends. When the configuration of the system is complete, the ‘delivery & configuration-phase’ ends.

The main goal of the delivery & configuration-phase is to provide a system that is configured based on the previously agreed upon customer requirements.

[24] In every invoice processing module implementation, a connection has to be made between this customer’s financial system and ProActive’s system, to make sure the two systems are synchronized. This is required because without this connection, optimal use of ProActive’s system is not possible. However, when this connection is not a connection that has been made by ProActive before, it has to be created by ProActive’s development department. In other words, when this connection has been made before, ProActive can reuse this earlier used connection. However, when it is a connection ProActive has never made before, their development department has to make this new connection possible, which means customization is required.

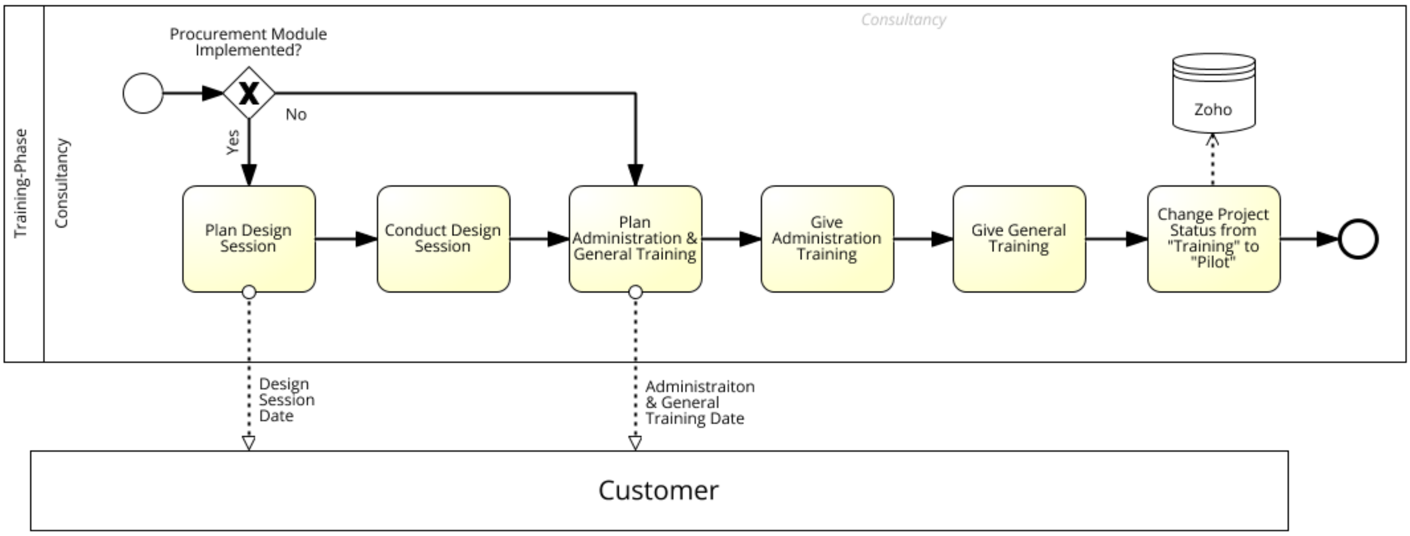
Figure 9 also mentions an exclusive gateway[25] "*Implementation of Largest Graduated Scale?*". Within the different modules ProActive offers, there are different versions in size. The size of the implemented module is called the "*graduated scale"* of the module. For example, the invoice processing module can be purchased with a limit of 1.750 processed invoices, but it is also possible to extend this limit to a maximum of 3.500, 7.500, 15.000, 30.000 or 60.000 processed invoices. To be able to accurately estimate the 'implementation size' of an implementation, ProActive has a standard template that shows the different steps of an implementation from a specific graduated scale of a specific module. This template shows that for the invoice processing module, there are four different possible types of implementations: one for the smallest two graduated scales, one for the third and fourth graduated scale sizes, one for the next-to largest graduated scale and also one for the largest graduated scale. The two smallest graduated scales are estimated to take a maximum of five days of consultancy work, while the largest graduated scale is estimated to take a maximum of eight days of consultancy work. This difference in required consultancy work is based on one different activity in every different type of implementation process. ProActive assumes the differences in complexity and size between tasks with the same name in projects with different implementation sizes is negligibly small. In other words, the difference in consultancy work is based on the extra steps that are required for the different implementation types. According to ProActive's implementation type templates, all the different steps in the different types of implementation processes are completely similar to the steps in the implementation type that applies to the previous graduated scale, except for the following exceptions:

- In an implementation of the two smallest graduated scales, the evaluation session is done by phone and the consultant only provides support *before* the customer goes live.
- In the implementation process of the two graduated scales after the two graduated scales of the smallest sizes, the consultant also provides support when the customer is going live, and this type of implementation has a separate 'go-live[26] & evaluation' session.
- The implementation process of the next graduated scale has a separate 'go-live' and a separate 'evaluation' session.
- The implementation process of the largest graduated scale of the invoice processing module has a separate 'review template' session, where the delivery template is reviewed an extra time to ensure that the template contains no mistakes.

How the lead time differs between the different implementation types based on these graduated scales will be further explored in chapter 5.

[25] Decision moment in the process.
[26] Go-live is when the system is rolled out to the complete customer organization

Figure 10: Training-Phase.

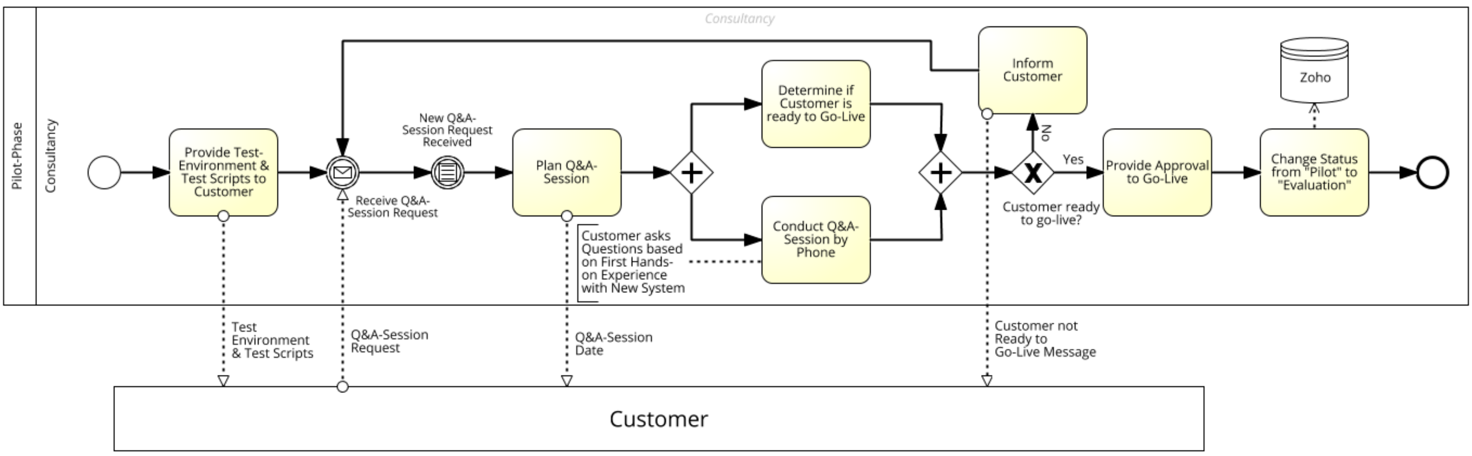


After the system is fully configured on the basis of the customer's wishes, the administration training is conducted with the main points of contact[27] from the customer company. In this administration training, the functionalities that are specifically important to know for those main points of contact are discussed. Also, in this session, these main points of contact have the possibility to ask some final questions before going into the pilot-phase. When the procurement-module is the to be implemented module, an extra 'design-session' is held before the administration training, where these main points of contact have the chance to experience the usage of the system by themselves for the first time. This session is only applicable for an implementation of the procurement-module, because ProActive believes that this module is more complex and requires more training than other modules.

After the administration training, the usage of the configured system is presented by ProActive's consultant to a small, representative group of employees from the customer company[28] in the 'general training'.

The main goal of the training-phase is to educate the customer about the basic functionalities of the configured system. ProActive believes this should help the customer in getting used to the new way of working.

Figure 11: Pilot-Phase



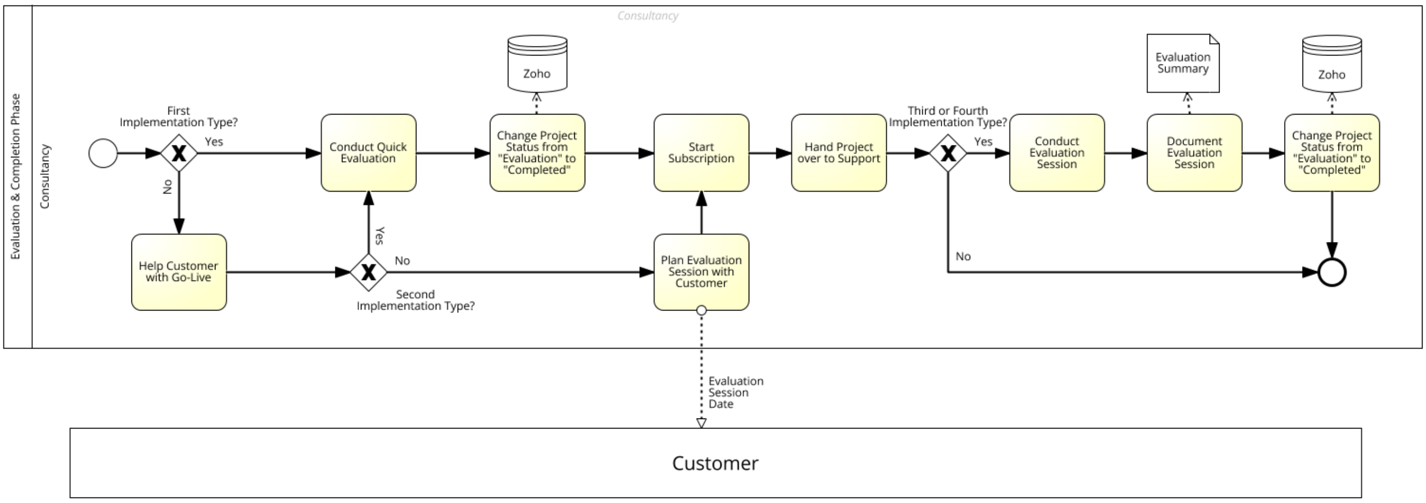
[27] Employee(s) of the customer company that take care of the communication between ProActive and the customer.

[28] Typically around two employees from every department that is going to work with the system.

In the pilot-phase, the representative group of customer employees that was also present at the general training-session starts to work with the system for the first time. Firstly, the consultant enables the test-environment for the customer and provides the customer with some test scripts. Later in the process, the customer can request for a Q&A-session, where the customer can ask questions. The consultant answers these questions by phone. Then, based on the customer's questions and the customer's progress, the consultant will determine in collaboration with the customer if the customer is ready to go-live[29]. When the customer and the consultant feel like the customer is ready to go-live, the pilot-phase ends and the go-live & evaluation-phase starts. The time that ProActive schedules for the pilot-phase is typically three to five weeks.

The main goal of the pilot-phase is to let the customer reach a state where they can efficiently work with the new system without the help of ProActive. This is important for the customer in able to make optimal use of the new system.

Figure 12: Go-Live, Evaluation & Completion-Phase



When a module of one of the two smallest graduated scales is being implemented, the first implementation type is applicable. In this implementation type, the evaluation is conducted by phone, and the customer has to roll the system out to all other employees by himself. When a module of one of the third- or fourth smallest graduated scales is being implemented, the second implementation type is applicable. ProActive does provide help with the Go-Live-phase of the customer with this implementation type. If the module that is being implemented is of a larger graduated scale than the previously mentioned graduated scales, ProActive first helps the customer to fully go-live, and then they plan a separate evaluation-session for a later moment. After the evaluation session is documented, the project can be closed and the implementation process then is officially completed.

The main goal of this phase is to roll the system out to the complete customer organization. Also, an important goal of this phase is to acquire 'lessons learned'[30] from the implementation project, which can be used by ProActive to conduct future implementation projects in a more efficient way.

[29] Go-Live: Roll out the system to all the employees.
[30] Lessons Learned: What about the implementation process should be taken into account in future projects: what was good and should be repeated, and what should be done differently in the future?

3.2 Project Administration

On the basis of the process descriptions in the previous section, this section will describe ProActive's project administration. On the basis of this description, the concept 'implementation lead time' will be defined in the context of ProActive.

3.2.1 Project Administration

Table 4 gives an overview of the different important steps in the implementation process where something should happen[31] to ProActive's project administration, based on the described process from the previous section. As mentioned earlier, a more detailed description of the different activities in the process is provided in Appendix VI.

Table 4: Project Administration in ProActive's Implementation Process

Activity Name	**Related Phase**	**Related Actor**	**Project Administration Changes**
Put Lead in CRM System	Acquisition	ProActive Sales	The name of the customer company, the main point(s) of contact from the customer company, the contact details of these point(s) of contact, the industry the customer company operates in[32], the module that is being implemented, the graduated scale of the module, the financial software that the customer has in use, and the amount of employees the customer company has are added to Zoho[33]. The first status of the project is '*Prospect*'.
Acquire Signatures for Contract	Acquisition	ProActive Sales	The signed contract is added to Zoho. The status of the project is changed from '*Prospect*' to '*Wait for Start*' in Zoho.
Assign Consultant to Project	Intake	ProActive Consultancy	The name of the consultant responsible for the project is added to the project in Zoho.
Plan Intake Meeting	Intake	ProActive Sales	When the date of the intake meeting is known, the status of the project is changed in Zoho from '*Wait for Start*' to '*Intake*'.[34]
Send Intake Summary	Intake	ProActive Consultancy	The intake summary is stored in Zoho. After the intake summary is sent to the customer, the status of the project is changed from '*Intake*' to '*Delivery & Configuration*' in Zoho.
Configure P2P-System	Delivery & Configuration	ProActive Consultancy	After the P2P-system configuration is finished, the status of the project is changed from '*Delivery & Configuration*' to '*Training*'.
Give General Training	Training	ProActive Consultancy	After the general training, the status of the project is changed from '*Training*' to '*Pilot*' in Zoho.
Provide Approval to Go-Live	Pilot	ProActive Consultancy	The status of the project is changed from '*Pilot*' to '*Evaluation*' in Zoho.
Conduct Quick Evaluation	Evaluation & Completion	ProActive Consultancy	If the implementation has no separate evaluation session[35], the status of the project is changed from '*Evaluation*' to '*Completed*'.
Document Evaluation Session	Evaluation & Completion	ProActive Consultancy	The documented evaluation session is stored in Zoho and the status of the project is changed from '*Evaluation*' to '*Completed*'.

[31] It also for example happens that an employee of ProActive by mistake does not change the status of a project when it should happen, which is why this is described as "*should happen*".

[32] Education, Healthcare, Other Non-Profit, or Business Services

[33] Zoho: ProActive's Customer Relationship Management-System (CRM), where their project administration is stored.

[34] The intake-phase starts for ProActive when the deal is signed, and the team leads are messaged about the new project, because then the planning of the intake-session starts. However, the status of the project is changed in Zoho from *'Wait for Start'* to *'Intake'* when the intake meeting is actually planned, because ProActive believes this leads to a more accurate project administration.

[35] In an implementation of one of the two implementation types of the smallest size, the evaluation is done right after the go-live.

The dates of when the status of a specific project is changed from one status to another is always registered in Zoho. ProActive had project administration available of projects with a '*Wait for Start'* status between 2011 and 2019. All projects with a '*Wait for Start'* status-date before 2016 only had a '*Wait for Start'* and a '*Completed'* status.

Furthermore, ProActive went from their in-house developed CRM-system to Zoho in 2019, which unfortunately had as a result that all projects with a '*Wait for Start'* date after January 1st, 2019 were registered with a '*Wait for Start'* date of January 1st, 2019.

3.2.2 Implementation Lead Time Definition

In this research, implementation lead time can be described as following: "*The time that passes between the start of an implementation project and the completion of the same implementation project".* The official start of an implementation is when the contract is signed and the project is assigned to a consultant and registered in Zoho. Unfortunately, the date of the registration of a consultant to a project is not shown in Zoho. However, when a consultant gets registered in Zoho, the intake-session is always planned within a week of time. The lead time of a project is measured in months, which means a maximum period of a week of time is a negligibly short period.
As mentioned in table 4, when the intake-session is planned, the status of a project is changed from '*Wait for Start'* to '*Intake'* in Zoho. Therefore, this research will treat the date of when the status of a project is changed from '*Wait for Start'* to '*Intake'* as the start date of an implementation project. Since the status of a project is changed from '*Wait for Start'* to *'Intake'* within a week of time after the contract is signed, the start date of ProActive's implementation process and the start date of the ASP implementation process are approximately the same[36].

The completion of an implementation project" in this research is defined as the moment that the consultant's role in the project is over, which always happens after the evaluation session. As mentioned before, after the evaluation session, a summary document of the evaluation is created, and then the status of the project is changed to *"Completed*". The date of this change of status is also registered in Zoho, which makes the implementation lead time in this research the time between the date of this completion and the date of the change of status from '*Wait for Start'* to '*Intake'* in Zoho. This is also the same as in the ASP process, as the last step in the ASP process is also the '*evaluation-step*'.

Lastly, in ProActive's project administration, only the dates of a change of project status were registered. The lead time of a specific phase in a project thus is the time that passed between the date that the project status changed to the name of that specific phase and the date when the project status was changed from the name of that specific phase to the name of the next phase.
The project administration did not contain data about the lead time of the different steps in the process.

[36] The ASP implementation process officially starts when the contract is signed.

3.3 Process Comparison

This section discusses how the ASP implementation process from the theoretical framework compares to ProActive's implementation process from section 3.1.

As described in section 2.1, to understand what causes the implementation lead time, it is important to understand the different activities of a process and how these activities are structured. Therefore, the two processes will be compared on a process-step level, to be able to analyse the differences in activities and structure. However, ProActive's implementation process describes the steps from their perspective, whereas the ASP implementation process in chapter 2 was mainly described from the customer's perspective (Figure 1, 2, 3). Therefore, the only part of the ASP implementation process that will be compared are those steps where the supplier is involved in, which are all steps in the installation & post-implementation phase, and the *'Collect and Analyse Vendor Proposal', 'Benchmark, Test and Arrange On-Site Demonstration'* and '*In-Depth Interview with Candidate Vendors'* steps.

Table 5 on the next page shows what step in ProActive's process is most similar to every different step in the ASP process where the supplier is involved in. Hereby, it is also described in what phase the specific step occurs. Lastly, for every step it is described what the similarities and differences are between the two different types of processes. This table will be used to draw a conclusion about the comparison of processes.

Table 5: ASP Implementation Process compared to ProActive's Implementation Process

ASP Step	*ASP Phase*	ProActive Similar Step	*ProActive Phase*	Similarities	Differences
Collect and analyse vendor proposal	*Selection & Acquisition*	Create new quotation	*Acquisition*	The steps in ProActive's process where the vendor's proposal is collected and analysed are the steps regarding the quotation.	In the ASP process, a vendor proposal is made before the first meeting between the customer and the supplier has taken place. ProActive on the other hand sends a first proposal to the customer after the customer has confirmed their interest in the product, after the demo meeting.
In-depth interview with candidate vendors	*Selection & Acquisition*	Conduct demo meeting	*Acquisition*	The demo meeting is the first "in-depth interview" with the customer in ProActive's process.	ProActive always shows a demo of the system to the customer in the first meeting. In the ASP process, a demo meeting is planned separately, and it only takes place if the customer requests for it.
Benchmark test and/or arrange on-site demonstration	*Selection & Acquisition*	Plan demo meeting	*Acquisition*	In both processes, a demo meeting takes place.	The on-site demonstration in ProActive's process is combined with the first interview. Also, the demo meeting does not always take place in the ASP process.
Contractual negotiation, order and take delivery	*Selection & Acquisition*	Acquire signatures for contract	*Acquisition*	In both processes, in this step the contract is signed.	In ProActive's process the contractual negotiation is done in the quotation steps, before the signing of the contract.
ASP modification	*Installation & Post-Implementation*	Configure P2P-system	*Delivery & Configuration*	In these steps, the standard package is altered on the basis of the customer's wishes and the configuration possibilities of the standard package.	The ASP process does not show a separate customization step, whereas in ProActive's process customization is required when a new connection with a customer's financial system is required.
Develop implementation planning	*Installation & Post-Implementation*	Conduct intake meeting	*Intake*	The implementation planning is developed in the intake meeting in ProActive's process. In both processes, the supplier helps with setting up the planning.	-
Internal procedure modification	*Installation & Post-Implementation*	-	*Evaluation & Completion*	-	ProActive does not aid the customer with their internal procedure modification. In the ASP process, the supplier does provide help in this step.
Provide training	*Installation & Post-Implementation*	Give general training	*Training*	Both processes have a training step.	In ProActive's process, an extra training is provided for more complex implementations like a procurement module implementation.
Data conversion and system transition	*Installation & Post-Implementation*	Help customer with go-live	*Evaluation & Completion*	ProActive's consultant helps rolling out the system to the entire organization in the go-live step.	ProActive does not help with the go-live step in an implementation of the smallest type.
Testing new system in user's environment	*Installation & Post-Implementation*	Provide test-environment & test scripts to customer	*Pilot*	Both processes provide the opportunity to test the new system in the user's environment.	In ProActive's process, the customer has to test the system by themselves, whereas in the ASP process the supplier provides help with testing.
System operation and maintenance	*Installation & Post-Implementation*	Hand over project to support	*Evaluation & Completion*	ProActive's support department is responsible for helping the customer with the system operation and maintenance. The customer is mainly responsible for the maintenance, but the supplier's support can always be called for assistance.	-
Performance evaluation	*Installation & Post-Implementation*	Conduct evaluation session	*Evaluation & Completion*	Both processes have an evaluation step in the process.	In ProActive's process, when the smallest implementation type is being implemented, there is no separate evaluation session. The evaluation is then conducted by phone.

3.4 Conclusion

As mentioned earlier, the impact of the factors from the literature model was only described related to the whole process. Hereby, it was not described if a factor for example has more impact in a specific step of the process, compared to in another step of the process. Since the process comparison was performed on a step level, factors from the literature model cannot be discarded based on the process comparison. Therefore, all factors from the literature model will be analysed in the context of the case study. However, based on the differences between the ASP- and ProActive's implementation process, it is possible to set expectations on how a difference between the processes could influence the implementation lead time:

- Since the start of a project is after the negotiations about the supplier's proposal, the difference in the acquisition-phase of the process does not influence the implementation lead time[37]. However, in this phase, a demo-meeting more often takes place in ProActive's process than in the ASP implementation process. As mentioned earlier, mainly the factor '*customer expectations*' is often already influenced in this demo-meeting. Therefore, it is expected that the factor '*customer expectations'* plays an even more important role in ProActive's implementation process than in the ASP implementation process.
- The consultant provides more active help in the ASP implementation process compared to in ProActive's implementation process[38]. Therefore, it is expected that the factor '*consultant's level of assistance'* has more impact on the implementation lead time in the ASP implementation process than in ProActive's process, because more consultancy assistance is provided in the ASP implementation process.
- It is expected that the *customer's skills, experience, and adaptability* have a higher impact on the implementation lead time in ProActive's implementation process than in the ASP implementation process, because the customer has to work more independently from the supplier in ProActive's implementation process. This means the customer should be more designated to its own skills, experience and adaptability compared to in the ASP implementation process.
- In ProActive's process, *customization* is always required when a new connection with the customer's financial system has to be made. According to ProActive, this type of customization is a relatively large time investment compared to other types of customization. The ASP process on the other hand does not show specific types of customization that always have to be made in a specific case. Therefore, it is expected that the factor '*customization'* has a bigger impact in ProActive's process than in the ASP implementation process.

When a specific factor that has a significant impact on the lead time of the ASP process does not come forward as significant in ProActive's process, these expectations based

[37] It might take more time to come to an agreement because negotiations are allowed in ProActive's implementation process, but this happens before the implementation process is started, which means this extra time does not directly influence the implementation lead time.

[38] For example in the "internal procedure modification and system testing" step.

on the differences between the two processes also help in explaining this difference in impact. For example, it can be explained if it turns out to be that the consultant's level of assistance does not have a significant impact on ProActive's implementation lead time, because the process comparison showed the consultant in the ASP process plays a bigger role in the project than the consultant in ProActive's process.

Moreover, to answer SQ 3b, we wanted to analyse the lead time of ProActive's implementation process on an activity-level. However, the project administration did not show the lead times of the different *activities* in an implementation project. Information about the lead times of the different *phases* of an implementation project was the most detailed level of information available in the project administration. Therefore, SQ 3b will later in this research be answered by looking at the lead times of the different phases in ProActive's process.

In summary, ProActive's implementation process is clearly an ASP type of implementation: except for the 'internal procedure modification', every different step of the ASP process can be recognized in ProActive's process and the definition of lead time for both processes is the same[39]. This does make it plausible that the factors from the literature model are also applicable on ProActive. However, as discussed above, the two processes also show some important differences. These differences could impact the way a specific factor from the literature model plays a role in ProActive's process. Later in this research, all factors from the literature model will be tested in the context of ProActive's process, to see how the impact of these factors is different in ProActive's process compared to in the literature model.

[39] Both processes have the same activity as the official start of a project and also have the same activity as the official end of a project.

4 Data Collection & Preparation

As mentioned before, ProActive's project administration can be used as a dataset for empirical investigation. This project administration first of all helps in putting the literature model to the test. Next to this, the project administration can later be used to investigate the impact of company specific factors[40] on ProActive's lead time, and to develop the quantitative model of lead time distribution for ProActive.
This chapter will start off by assessing if the factors from the literature model are also present in ProActive's project administration. Hereby, these factors will be operationalized[41], to justify how these factors will be tested for ProActive. Hereafter, the problem of missing data will be addressed by removing insufficient cases from the dataset and by adding data to sufficient cases through interviews and surveys. Lastly, it will be described how the dataset will be split up in a test set and a training set for the machine learning.

4.1 Operationalization

As section 3.2 shows, ProActive's project administration contained information about several different aspects of the implementations:

- The name of the company that underwent the implementation.
- The module that was implemented.
- The industry the company operates in: healthcare, education, or another non-profit industry, or business services.
- The amount of employees the customer company has.
- Stakeholders relevant to the project: The related account-manager, the assigned consultant, and the main contact points from the customer with their contact details.
- The graduated scale of the module that was implemented.
- The support calls the customer did after having the system implemented and on what date the support calls occurred.
- The financial software used by the customer that ProActive had to link and synchronize their system with.
- The starting date of the implementation.
- The end date of the implementation.

Based on the available information in ProActive's project administration, some factors that were found in literature will be tested with the original project administration. These factors are shown in table 6.

[40] Factors that have an impact on ProActive's lead time, but were not mentioned in the theoretical framework.
[41] Translating an abstract concept to make it measureable with data.

Table 6: Literature model operationalization with project administration.

Literature Factor	Project Administration	Explanation
5: User Adaptability	Amount of support calls within six months after the implementation was finished	It is assumed that a customer that required more support had a lower level of adaptability to the new system than a customer that required less support. Therefore, the impact of the factor 'customer adaptability' was tested by looking at the difference in lead times between projects where an above average amount of support was used and projects where an under average amount of support as used within six months after the implementation was finished.
6: Customization	First time connection with a customer's financial system	The impact of the factor 'customization' will be tested by looking at the difference in lead time between projects where this connection was new to ProActive, and projects where this connection was familiar to ProActive. When this new connection is required is described in section 3.1.
9: Implementation Size	Different implementation types based on graduated scale and different modules	As mentioned in section 3.1, ProActive has four different implementation types based on graduated scale, where a higher graduated scale often means a bigger sized implementation type. Next to this, ProActive states that their procurement module has a higher level of complexity than the invoice processing module, which has a higher level of complexity than the contract management module. Therefore, since the 'complexity-factor' is also an important part of implementation size (Chaturvedi et al, 2011), the impact of implementation size will also be tested by looking at the difference in lead time between projects from different modules.
10: Consultant's Level of Assistance	Consultant in the first half year of employment at ProActive	ProActive claims it takes around half a year for a consultant to get out of their 'learning period'. It is assumed that a consultant with less than half a year of employment at ProActive provides a lower level of assistance than a consultant with more than half a year of employment at ProActive.

4.2 Missing Data

In analysing ProActive's project administration, the problem of missing data was encountered. This problem consisted of two aspects:

1. Some cases had incomplete data available because they were not sufficiently registered in ProActive's project administration.
2. The other eleven factors from literature, that are not discussed in table 6, could not be tested with the data that was initially available in ProActive's dataset.

The first aspect of the missing data problem was addressed by discarding the cases from the dataset that had insufficient data available. The missing data about the other eleven factors from literature was collected through interviews and surveys.

4.2.1 Discarding Data

As mentioned in section 3.2, projects with a start date after the 31st of December 2018 were registered with the wrong start date. Also, ProActive only fully registered the dates of the different phases of the implementation process for projects with a start date after December 31st, 2015. Therefore, the only part of the dataset that would lead to reliable results for this research were all projects with a start date between January 1st, 2016 and January 1st 2019.

ProActive has three modules that are part of the P2P process: the invoice processing module, the procurement module, and the contract management module. Every different implementation of a different module is assigned to a different consultant from ProActive and treated as a new separate project. Due to time constraints, it was not possible to perform this research on all modules that are part of the P2P process. Also, the invoice processing module had a more complete set of data available than the other two P2P modules[42]. Therefore, this research mainly focused on projects regarding the invoice processing module.

ProActive's dataset showed that the invoice processing module is almost always the first module to be implemented by a customer. Not all potential factors that influence the implementation lead time are also applicable to the other modules. For example, in the delivery & configuration-phase, a connection between ProActive's system and the customer's financial system always has to be made when the invoice processing module is being implemented, but never has to be made when another module is being implemented, because this connection then already exists. As mentioned earlier, having to make this connection can be the cause of customization being required, which can have an impact on the implementation lead time.

After discarding data, a sample set of 168 invoice-processing implementations was left to analyse. These 168 cases will further be referred to as the "*complete sample set*".

4.2.2 Collecting Additional Data

As mentioned earlier, the missing data about the other eleven factors from the literature model was added through interviews and surveys. This sub-section will discuss the interview cases and the survey questions that were used to add this missing data to the available dataset. The sub-sample set that followed from these interviews and surveys can be found in Appendix VII.

4.2.2.1 Interviews

After fine-tuning the dataset, the interviews were conducted. As mentioned earlier, one of the two main purposes of the interviews was to collect data about the factors that could not be operationalized with the original project administration. The other main purpose of the interviews was to find company specific elements, which will be further elaborated on in section 5.1.
This sub-section will describe why the interviewees were interesting to interview. Also, the structure of the interviews will briefly be described. Lastly, the different implementation projects that were the subject in the conducted interviews are summarily described at the end of this sub-section.

Eisenhardt (1989) mentions that, for the results of a case study-research to be reliable, four to ten different cases should be analysed. When having less than four cases, it is

[42] ProActive's dataset had complete data available about 168 invoice-processing module implementations, 32 procurement module implementations, and 34 contract-management module implementations.

not likely that enough data is gathered to provide convincing evidence with (Eisenhardt et al, 1989). On the other hand, having more than ten cases often makes it too difficult to deal with the amount of gathered data and the complexity of the data (Eisenhardt et al, 1989). For this reason, interviews were planned with six different employees from six different customers of ProActive. From the six different interviewed cases, two projects had a relatively high lead time, two projects had an average lead time, and the two other projects had a relatively low lead time. This selection was made because this opened up the possibility to see what potentially caused the differences in implementation lead times.

All interviewed cases were derived from the complete sample set of 168 cases. All interviewees were ProActive's main point of contact during the implementation process. The reason for choosing these main points of contact is that these people interacted more with ProActive than any one of their colleagues, which means these people knew the most about how the collaboration with ProActive went. This ensured that the interviews were held with the most well informed people in the customer's organization.

However, as mentioned before, all cases from the complete sample set had a start date before 2019. As a result, the first interviewee[43] stated it was challenging to remember everything about the implementation, because the implementations happened at least more than a year before the interviews took place. Therefore, it was decided to conduct interviews about the most recent available projects in the dataset. For this reason, only cases with a start date in 2018 were interviewed, ensuring that the respondents could recall what happened as accurately as possible.

The organizations to be interviewed were selected on the basis of the information retained from ProActive's dataset. Customers that underwent an implementation with an interesting lead time were contacted via email. These emails emphasized that the setting of the interview to take place in would be the preferred setting of the interviewee, aiming to make the respondent feel as comfortable as possible. This resulted in some interviews being conducted online, but the interviews were all held face-to-face to enable the interviewer to make observations and notice non-verbal language. The respondents were selected based on the advice of the consultant that was assigned to the specific project when the project was carried out. The interviewees all had similar jobs within their respective companies, either in administration or financial management.

The interviews were semi-structured and consisted of the same structure. The interviews all started with a brief introduction and a request for the respondent's approval to record the interview. All interviewees approved and continued with introducing themselves. After this, the interviewee was asked how they ended up choosing for ProActive and why ProActive had the edge over its competitors.

In the main part of the interviews, several questions were asked about the different steps of ProActive's implementation process. These questions were set up on the basis of the process model that was created earlier in this research. The questions were aimed on how the respondents thought these steps went. Hereby, the focus of the questions was

[43] The case project related to the first interviewee had a start date in 2018.

on what factors the interviewee thought mainly determined the eventual implementation lead time, and how they think the lead time of a P2P implementation project is influenced in general. At the end of every different phase in the interview, the respondent's answers were summarized to make sure the respondent was understood correctly. Within a day of time after every interview, the interviews were summarily transcribed. The full list of interview-questions can be found in Appendix III.

Table 6 provides an overview of the characteristics of the different interview cases. A more detailed description of the interview cases can be found in Appendix IV.

Table 6: Interview Cases

Company No.	Interviewee Job Function	Company Size	Industry	Lead Time in Months
1	Financial Bookkeeper	Small	Business Services	8.5
2	Application Manager	Average	Education	5
3	Finance Employee	Average	Business Services	12
4	Customer Administration Services	Small	Business Services	2
5	Head of Finance	Small	Education	4
6	Head of Finance	Large	Healthcare	5

4.2.2.2 Surveys

As mentioned in the previous section, next to conducting interviews, the missing data about the factors from the literature model was acquired via surveys. Data about six of the remaining eleven factors could be added with the interviews and surveys. Table 7 shows the survey questions that were used to acquire the missing data for these factors. The full list of questions and multiple choice answer-possibilities of the survey-questions are shown in Appendix VIII.

Table 7: Acquiring missing data with survey questions

Literature Factor	Survey Question
3: Customer Skills / Experience with Similar Implementations	• How would you estimate the level of IT-knowledge of the employees from the company where you worked during the time of the implementation? • Was the project manager experienced with similar implementation projects? • Did you experience a lot of resistance from within the company when the system was being implemented? Why do you think that is?
7: Resource Allocation	• In all steps of the project, the required expertise was present in the right places? • Where was it not present and what caused this? • Did this cause any problems and why?
8: Organizational Fit	• Did you experience a lot of resistance from within the company when the system was being implemented? Why do you think that is?
12: Division of Roles	• On forehand, we knew exactly what ProActive expected from our side and what we could expect from their side. • Were things realized in a different way than what you wished how it would be realized on forehand? If yes, what was realized differently?
13: Customer Expectations	• On forehand, we knew exactly what ProActive expected from our side and what we could expect from their side. • We had a clear image of the possibilities of the Spend Cloud.

	• How did ProActive help to create this clear image?
13a: Prototype Availability[44]	• Before / during the implementation process, we had the possibility to test the usage of the ProActive module (for example by being in contact with a similar organization that already had the spend cloud in use, or a demo environment) • In what way could you experience this usage?

Data about the factors '*Project Management'* and '*Customer Preparation'* could also be collected with interviews and surveys. However, this data had some limitations, because collecting missing data for these factors does not lead to as valid and reliable survey/interview responses as collecting missing data for the factors that are mentioned in table 7. The reason for this is the questions related to these factors are likely to trigger the '*response bias*' for the respondents. The response bias can occur when a question seeks for an answer that makes the respondent admit to an undesirable trait (Furnham, 1986).

The factor '*project management'* is a factor that is prone to the response bias because, for example, a specific project manager could be friends with the respondent, which means the respondent will be less likely to rate the befriended project manager's skill set as insufficient. This could also work the other way around when the respondent dislikes the project manager.
In an attempt to avoid this response bias, we tried to estimate the impact of this factor by asking the respondent about the project manager's experience with similar implementations, and if the project manager tightly monitored the progress of the planning[45].

The response bias is also likely to occur for questions related to the factor '*customer preparation*'. The reason for this is that not preparing for the implementation sufficiently is something that does not make the customer look good, and he thus is less likely to admit to.
In an attempt to avoid the response bias, we tried to estimate the impact of this factor by asking the respondent to describe how they prepared for the implementation, and if on forehand they knew exactly what they wanted to achieve with the implementation.

The remaining three factors from the literature model were discarded for the following reasons:

- *Top Management Support.* Even though literature rated this factor as one of the most influential factors, this factor could not be tested because ProActive's dataset contained no finished projects where top management had an influence. As this is the case, there was no data available to test whether this factor has any influence. All projects in the dataset that did show that the customer's top

[44] The only way ProActive's customer can experience the usage of the system before it is implemented in their organization is through the availability of a demo environment or a 'referent'. Hereby, a referent is an organization similar to the customer's organization that already has the spend cloud in use, where the customer can look how the system works in the environment of that similar organization. This came forward out of an interview with one of ProActive's account-managers.

[45] This was also done because the factor '*project management'* has some overlap with the factors '*experience with similar implementations'* and '*project planning':* a project manager that has experience with similar implementations is more likely to know what to do to sufficiently manage the project, and the project manager is also mainly responsible for the monitoring of the project planning.

management had an influence on the project were suspended before the project was finished.

- *Product Quality.* In every single case of the complete sample set, the same product was implemented. Therefore, since no data from ProActive's competitors was available, the dataset could not be divided into different groups based on a difference in product quality.
- *Training & Education.* All survey- and interview respondents rated the training as sufficient, which means the difference in lead time between sufficient / insufficient training could not be tested. Also, all survey- and interview respondents thought the training did not influence the implementation lead time.

4.3 Machine Learning Preparation

As mentioned before, we want to apply machine learning on our dataset to develop a quantitative model of the lead time distribution at ProActive. An important part of machine learning is training the model on the basis of a training set, and then testing the performance of the model on a test set (Brownlee, 2020). Therefore, before machine learning can be applied, the dataset needs to be split up in a training- and a test set. This was prepared as follows.

We created two different datasets; one on the basis of the complete sample set of 168 cases and one based on the interview & survey sub sample-set of 23 cases. Hereafter, the "slice sample" function in R studio[46] was used to split up the dataset into a training- and a test set. This function randomizes the contents of the training- and test set, based on a customizable percentage of the data. Hereby, both datasets were split up in a training set with 78% of the dataset, and a test set with the other 22% of the data.

[46] Programming tool for statistical computing and graphics (R Core Team, 2020)

5 Analysis & Results

This chapter will describe the results that came forward from the analysis of the data that was gathered in the previous chapter. The main goal of this chapter is to provide an answer to the remaining SQ's: 3, 4, 5, and 6.
Firstly, SQ 3a will be answered by looking at the actual lead time distribution of the complete sample set. Subsequently, it will be determined what phase in ProActive's process has the highest average lead time, to answer SQ 3b.
For SQ 4, to take into account all potential important factors, the company specific elements will be discussed. This makes it possible to see what other factors, next to the factors that came forward from the theoretical framework, have an influence on the average implementation lead time.
On the basis of the factors from the theoretical framework and the company specific elements analysis, the hypotheses will be formulated and tested. This contributes in answering SQ 4. On the basis of the testing results, the hypotheses will either be accepted or rejected. The accepted hypotheses will be used to develop a qualitative model of lead time distribution, which shows what the most important factors are that influence ProActive's lead time.
Hereafter, to provide a complete answer to SQ 4, the impact of the different factors that influence the implementation lead time will be quantified by using predictive modelling methods. These predictive modelling methods will also be used to develop a quantitative model of ProActive's lead time distribution, which answers SQ 5. Lastly, SQ 6 will be answered by evaluating the quantitative model and by looking at what factors from the answer to SQ 4 can be influenced by ProActive.

5.1 Data Exploration

5.1.1 Actual Lead Time Distribution at ProActive (SQ 3a)

Firstly, the implementation lead time mean of the 168 cases that were analysed was calculated, to get an indication of the current 'size of ProActive's implementation lead time problem'. The implementation lead time mean of all 168 projects is 5.85 (Figure 13).

Figure 13: Lead Time Data Distribution of ProActive's Project Administration

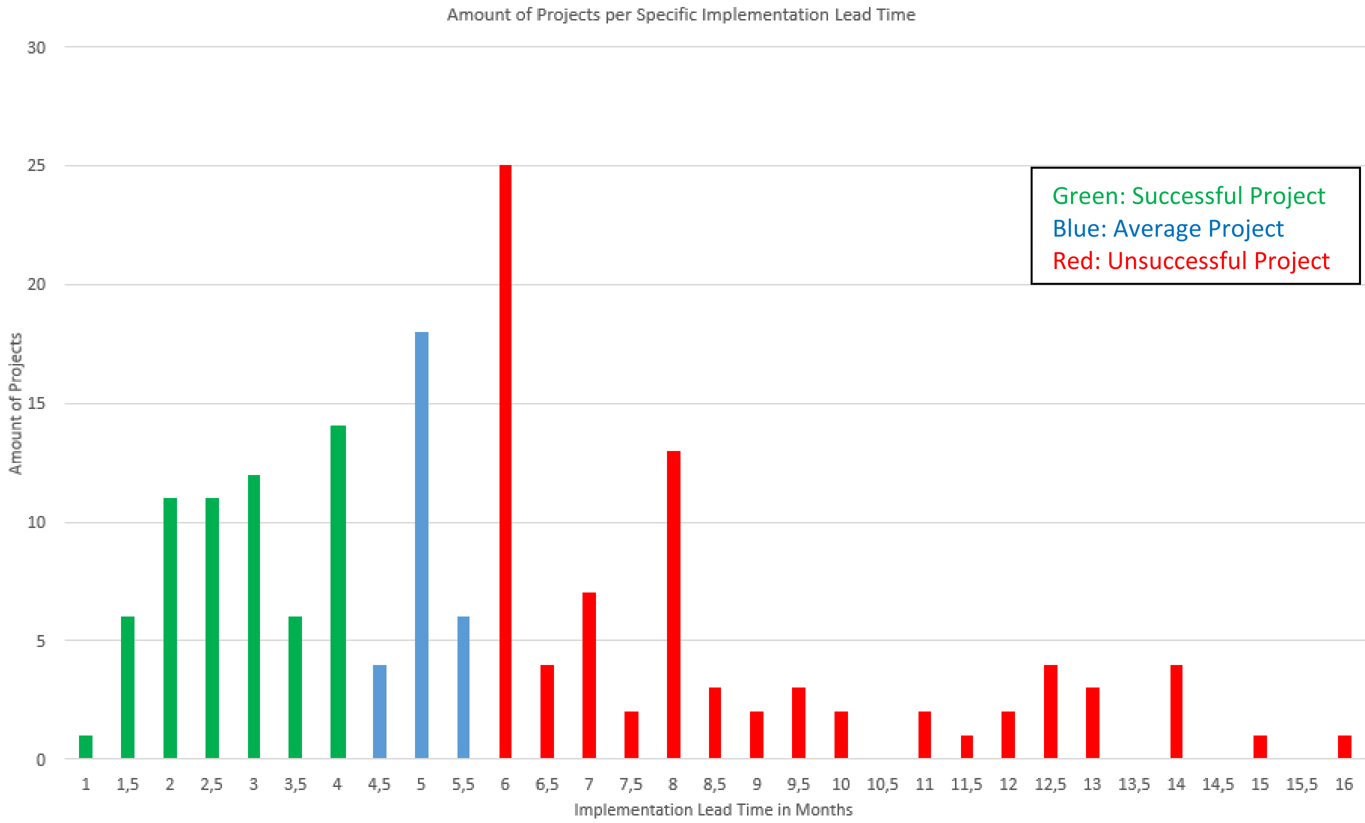
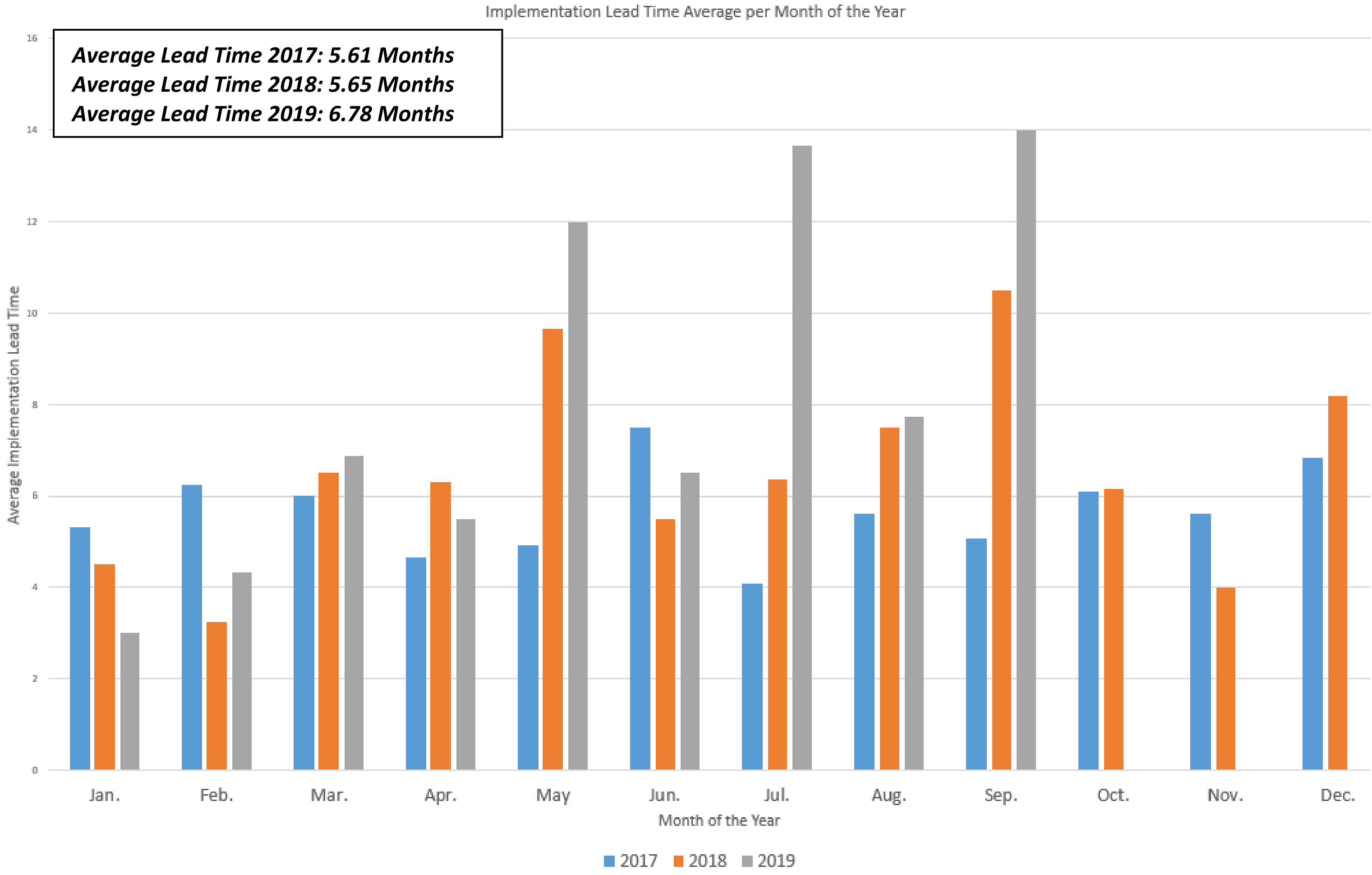


Figure 13 shows that *most* of ProActive's implementation projects have an implementation lead time of six months, and *second most* of the implementation projects have a lead time of five months. As mentioned in the introduction, projects with a minimum lead time of six months were rated by ProActive's consultants as unsuccessful, whereas projects with a maximum lead time of four months were rated as very successful. Not only is the mean of the dataset close to six months, also, as can be seen in Figure 13, almost half of the projects (79 out of 168) have an implementation lead time that is at least six months. This shows that ProActive's implementation lead time at the moment is not as they would desire.

After calculating the mean of the complete sample set, the average lead time of all projects was compared to the different months and years where the end dates of the projects were, to see how the lead time developed over time (Figure 14):

Figure 14: Average Lead Time per Month of the Complete Sample Set



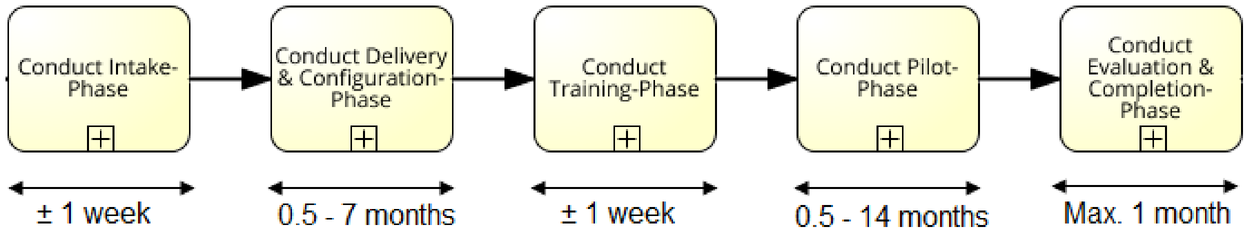
Whereas the average implementation lead time of the projects with an end date in 2017 and the projects with an end date in 2018 are almost similar, the projects with an end date in 2019 have a relatively higher average lead time. This does not mean that the more recent projects (2019) take more time than the older projects (2017 and 2018), because there are less projects from 2019 available in the dataset. The reason for this is that, as mentioned before, the projects with a start date after 31/12/2018 are not up for analysis. Therefore, it can be accounted for that the projects with an end date later in 2019 have a higher average lead time, because a project with an end date in September 2019 for example has an implementation lead time of at least eight to nine months. This is the case because there are no projects with a start date in 2019, which means the earliest starting month of a project in the complete sample set is December 2018.

5.1.2 Lead Time Distribution Across ProActive's Process (SQ 3b)

Now that we have determined the average lead time at ProActive, the question remains how the lead time is divided across the different phases of the implementation process. Hereby, it will also be determined what phase in the process has the highest average lead time, to see what phase in the process is the main bottleneck.
The dataset did not contain a clear separation between the delivery part of the 'delivery & configuration-phase' and the configuration part of the same phase, which is the reason why these two parts will only be analysed as a whole.

As mentioned in section 3.2, ProActive's project administration shows the minimum and maximum time a specific phase in the process can take. This is depicted in figure 15, by zooming in on figure 6 from section 3.1.

Figure 15: Approximate lead time of the different phases in ProActive's implementation process



As figure 15 shows, the higher than desired average implementation lead time is caused in either the 'pilot-phase' or the 'delivery & configuration-phase'. These two phases are also the only parts of the process where the supplier has to wait for the customer to finish their task proficiently, before they can progress with the project (Figure 9 & 11, section 3.1). Also, the delivery & configuration phase is the main phase in the process where consultancy work is required.

109 out of 168 cases from the complete sample set had data about the 'delivery & configuration-phase' available. This data showed that the 'delivery & configuration'-phase had an average lead time of 2.75 months (Figure 16).

105 out of 168 cases from the complete sample set had data about the 'pilot-phase' available. This data showed that the 'pilot-phase' had an average lead time of 3.83 months (Figure 17).

Figure 16: Delivery & Configuration-Phase Data Distribution

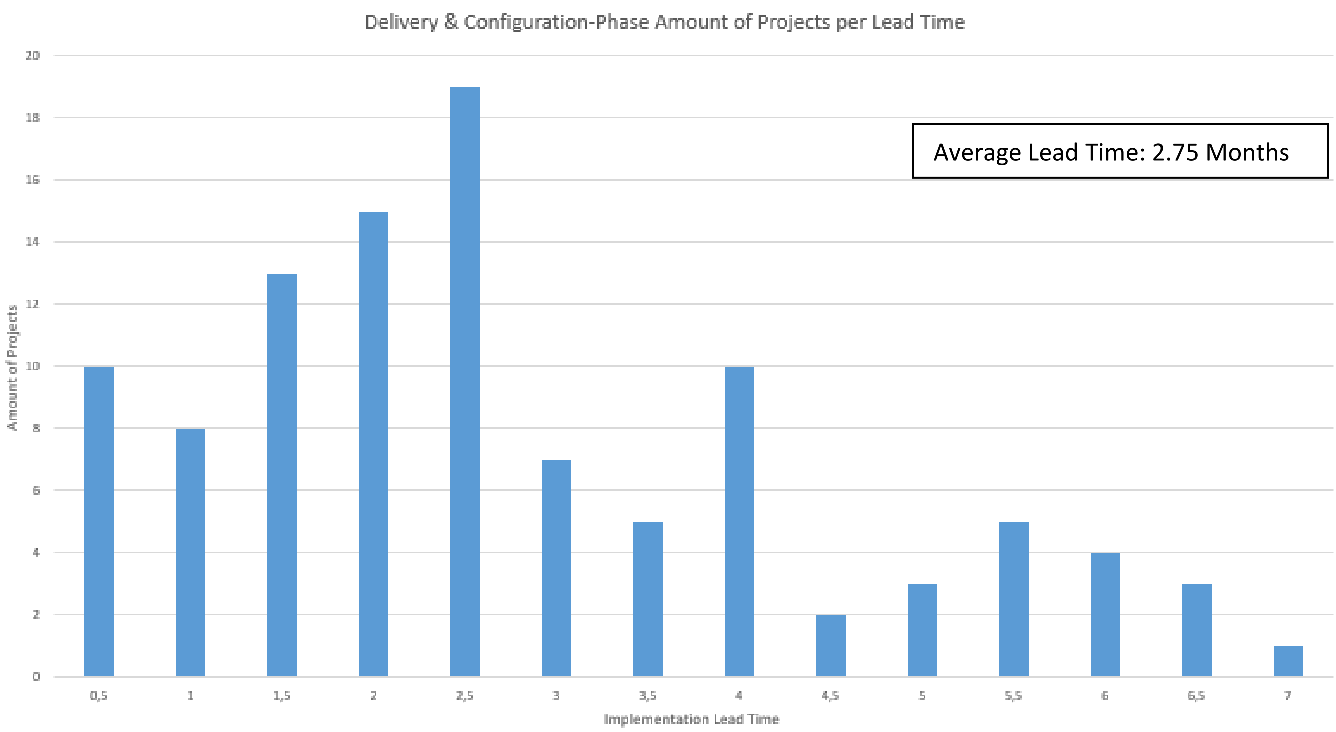
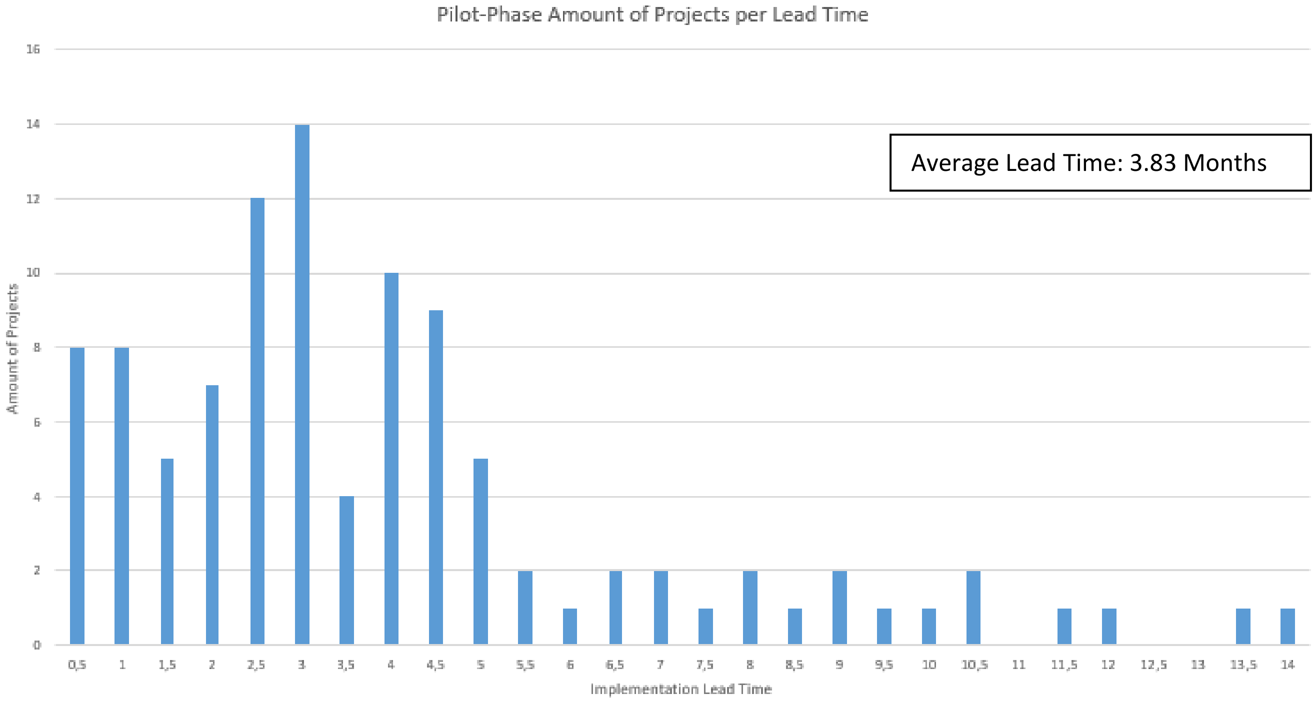


Figure 17: Pilot Phase Data Distribution



According to ProActive's standard process, the pilot-phase should take no longer than three to five weeks. The reason for this is that in this phase, the configuration of the system is already completed on the basis of the customer's requirements. Also, because the Spend Cloud is rated as very user friendly, it should not be difficult for the customer to get ready to go-live with the new system within three weeks of time after the training was conducted. Therefore, it was expected that most of the delays in implementation lead time are caused in the 'delivery & configuration-phase'. However, as figure 17 shows, the lead time of the 'pilot-phase' exceeds this period of three to five weeks[47] very often. Also, the average lead time of the 'pilot-phase' is more than a month longer than the average lead time of the 'delivery & configuration-phase'. This shows that ProActive's implementation process is mostly being delayed in the pilot-phase, where a small group of employees from the customer company starts to work with the system for the first time. As figure 11 from section 3.1 showed, in this phase these employees ask questions to ProActive's consultant in Q&A-sessions, based on the first hands-on experience they have with the configured module, in an attempt to optimize the use of the system for the customer company. The relatively high lead time of this phase indicates that for some customers it is more difficult to adapt to the new way of working than it is for others, and that some customers are not ready to roll the system out to the rest of the company within three weeks of time after the training. What potentially causes this will be discussed later in this chapter, on the basis of the exploratory data analysis and the interviews.

5.1.3 Company Specific Elements

As mentioned before, we also want to include company specific elements, to be able to develop an as accurate quantitative model of the lead time distribution as possible. Therefore, an exploratory analysis of the project administration was performed, to see if there are company specific factors that were not mentioned in the theoretical framework.

[47] Three to Five weeks is around one month of time.

Next to this, as mentioned in section 4.2.1.1, the interviews were used to derive what the interviewees deemed to be the most important factors in their implementation process. This sub-section will discuss what company specific elements emerged from the exploratory analysis and the interviews.

5.1.3.1 Exploratory Analysis of ProActive's Project Administration

The exploratory analysis of the project administration showed that, next to the factors from the literature model, there are four company specific factors that could significantly impact ProActive's lead time:

- The month of the year that a specific project ended in.
- The industry that a specific customer was operating in: education, healthcare, business services, or other non-profit.
- If a specific customer implemented only the invoice processing module at the same time, or also another module next to the implementation of the invoice processing module at the same time.
- If a specific project did or did not have a deadline around new year's eve.

The cases in the project administration were divided in different groups based on the aspects of the projects that are mentioned above:

- Twelve different groups based on in what month the end date of a specific project was.
- Four different groups based on the different industries where the customer companies operate in.
- Two different groups where one group of projects implemented only the invoice processing module at the same time and the other group also implemented the procurement- or the contract management module at the same time[48].
- Two different groups, comparing the difference in lead times between projects with a deadline within a month of new year's eve and the other projects in the complete sample set.

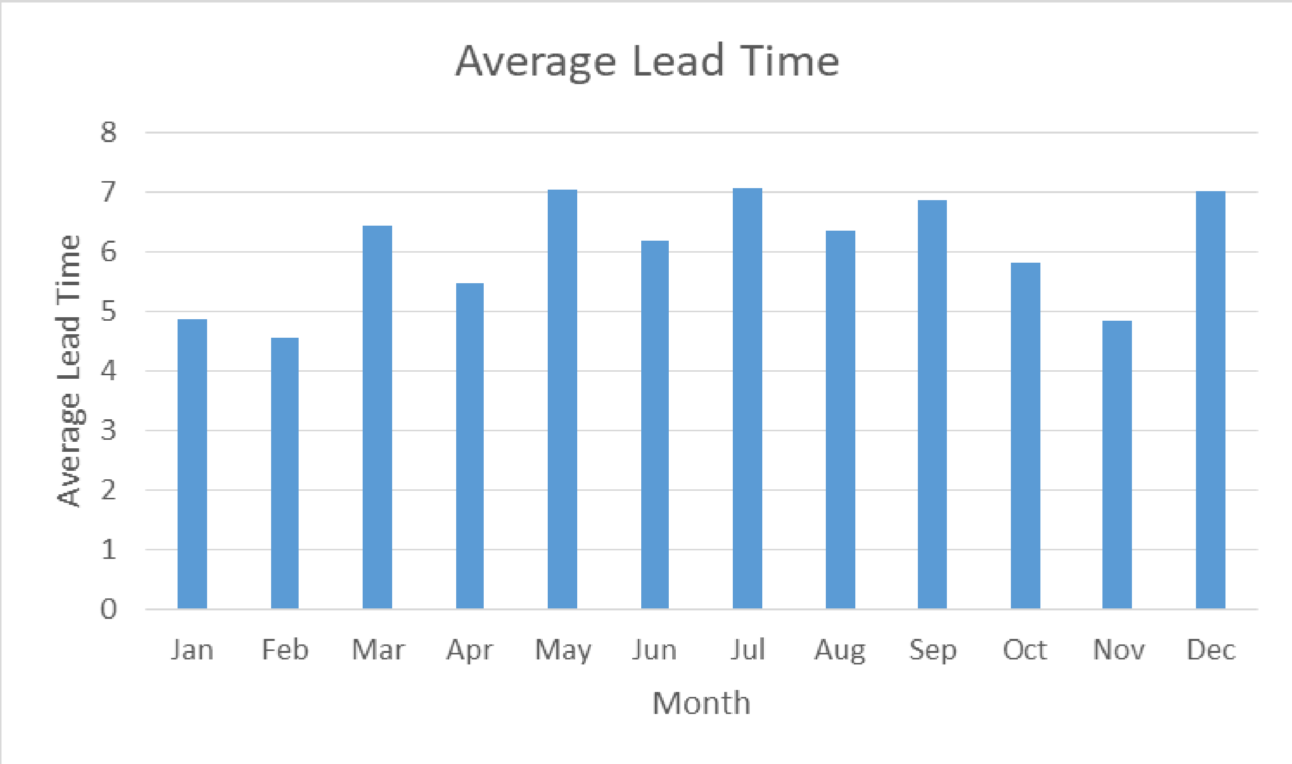
The influence of a specific aspect of an implementation on the implementation lead time was measured by seeing how the lead time would change if a specific group would be excluded from the full list of implementations. Also, the lead time means of the specific groups were calculated, to see how these differed from the means of the other group(s) and the complete dataset. An overview of the data on the different groups can be found in a table at the end of this sub-section.

For every grouping analysis, it will be described how the data implies the specific factor impacts ProActive's lead time. The significance of the impact of these factors will be tested in the next section.

[48] ProActive treats every implementation of a different module as a separate implementation project. These two different groups were made by creating one group where the start date of a specific invoice processing project at a specific customer company was the same as the start date of the implementation of one of the other two P2P modules at the same company, and one group where only the invoice processing module was implemented at a specific company, or the start date of one of the other modules was later than the start date of the invoice processing module implementation.

Grouping Analysis 1: Implementation lead time of the different months of the year:

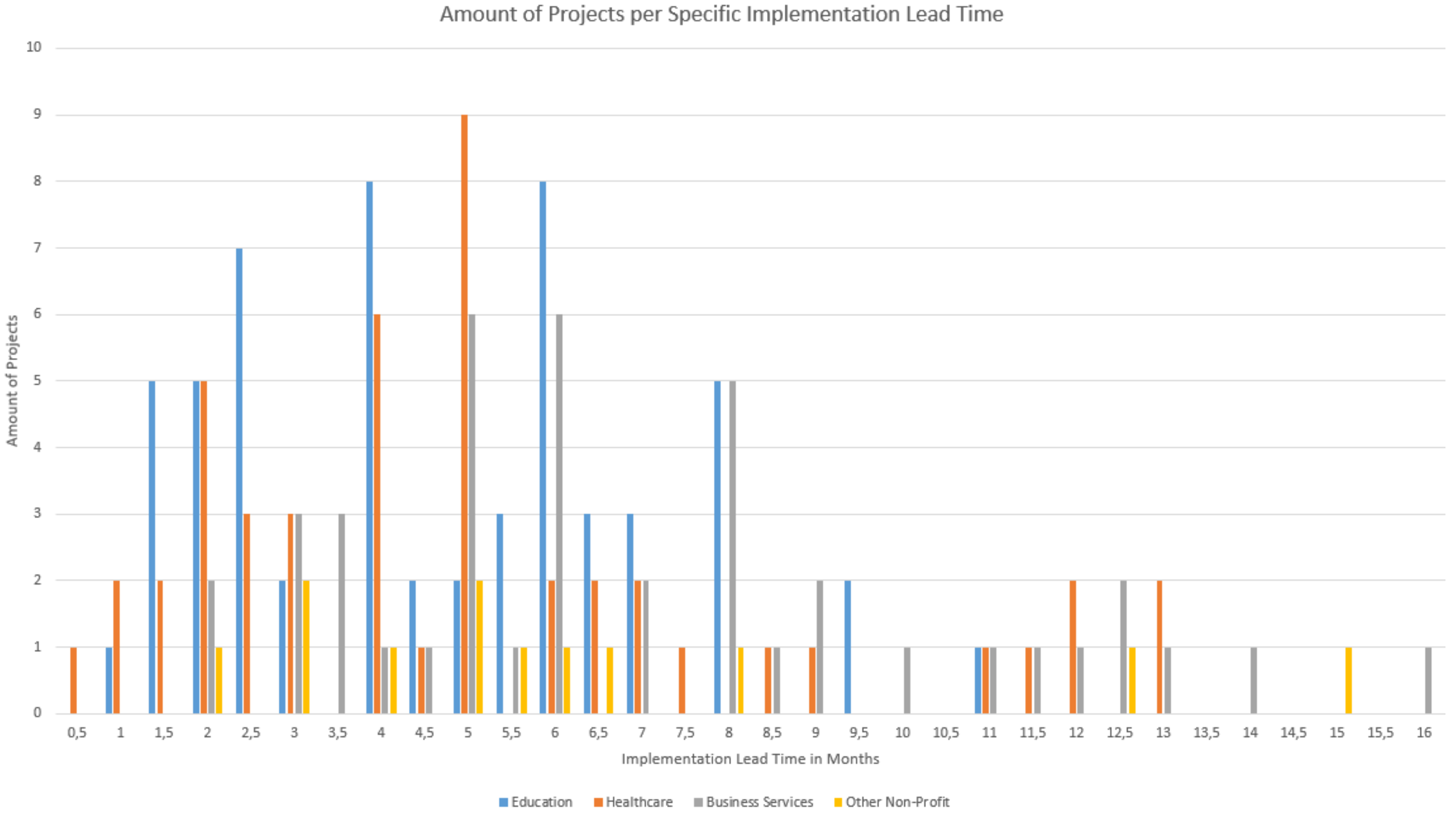
Figure 18: Average Lead Time End Date Month



This analysis implies the average implementation lead time of projects with an end date halfway through the year (May, June, July) is higher than the implementation lead time of projects with an end date at the beginning of the year (January, February).

Grouping Analysis 2: Implementation lead time of the Industry the companies from the dataset operate in and ProActive's experience with those specific industries:

Figure 19: Different Industries Data Distribution



- The mean of the 57 projects with customers from the education industry is equal to 4.70 months.
- The mean of the 47 projects with customers from the healthcare industry is equal to 6.15 months.
- The mean of the 20 projects with customers from other non-profit companies is equal to 6.23 months.
- The mean of the 44 projects with customers from the business services industry is equal to 6.85 months.

The analysis implies that the industries where ProActive is most experienced[49] with have a lower average lead time than the industries where ProActive is relatively less experienced with[50].

[49] Non-profit vs. Commercial, and ProActive's experience within those industries.

[50] Most of ProActive's customers are from the education industry, after education most customers are from the healthcare industry, a little less amount of customers are from the business services industry, and the least amount of ProActive's customers are other non-profit companies.

Grouping Analysis 3: Implementation lead time of projects with a planned deadline outside the margin of a month within new year's eve vs. the implementation lead time of projects with a planned deadline within a month of new year's eve.

Figure 20: Deadlines around new year's eve data distribution

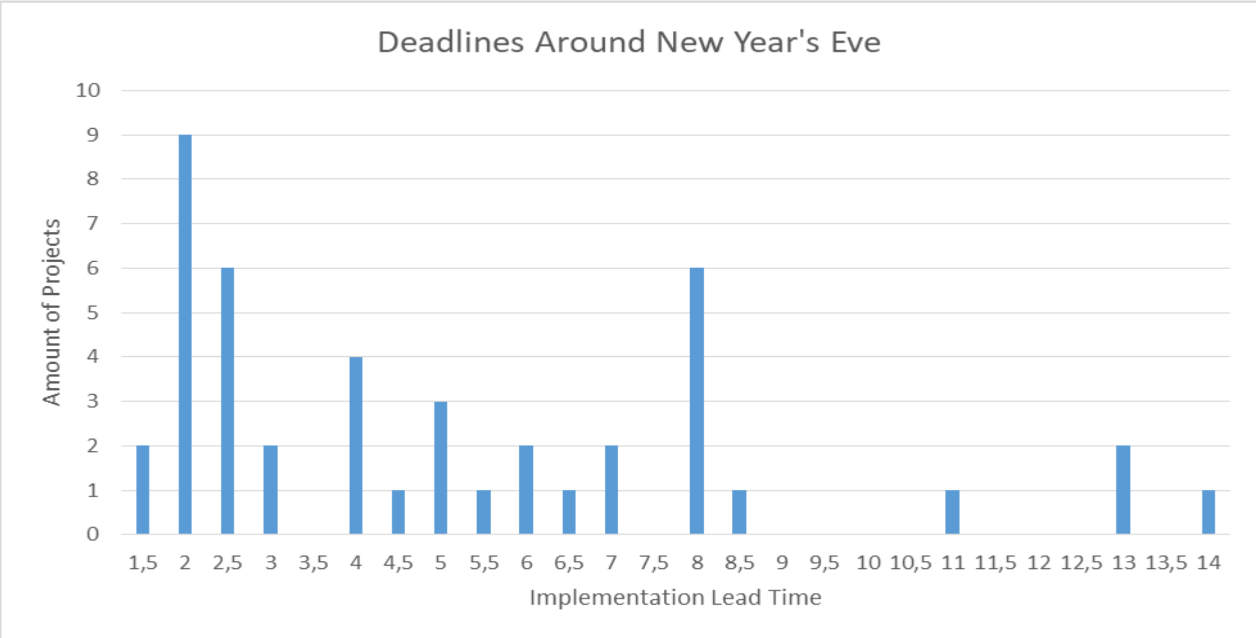
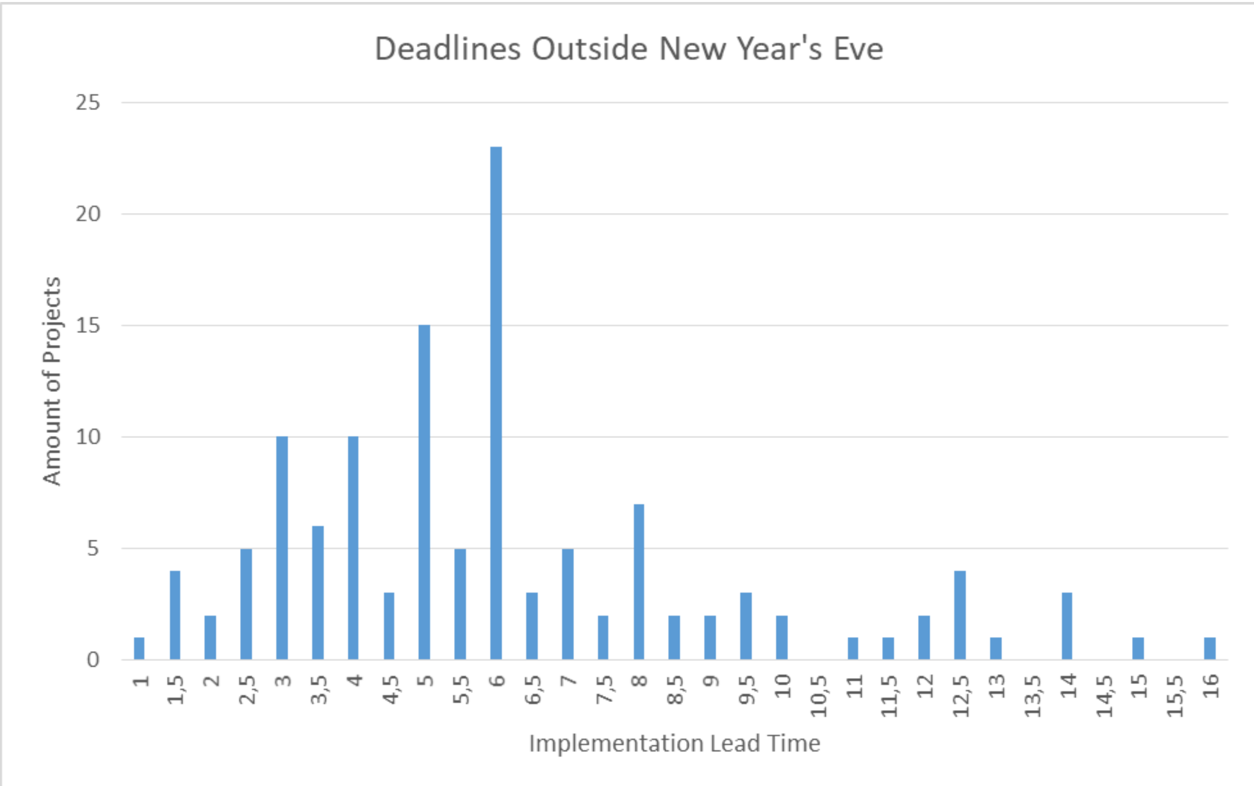


Figure 21: Deadlines not around new year's eve data distribution



44 projects from the dataset have a deadline within a margin of one month around new year's eve. These projects have a mean lead time of 5.07.

The other 124 projects that do not have a deadline within the margin of a month around new year's eve have a mean lead time of 6.13 months.

"*Having higher levels of temporal consensus increases the chance that project teams meet their deadlines as it relates to coordinated action and meeting deadlines*" (Gevers et al, 2009). Gevers et al (2009) describes temporal consensus as "*the extent to which team members have a shared understanding of the temporal aspects of their collective task*". This grouping analysis implies that when a company wants to finish their project before going into the new year and the schedule is tight, the level of temporal consensus is higher, and therefore the implementation lead time is shorter.

Grouping Analysis 4: Implementation lead time of cases implementing invoice processing module only vs. implementation lead time of cases implementing multiple modules at the same time

Figure 22: Multiple Modules Data Distribution

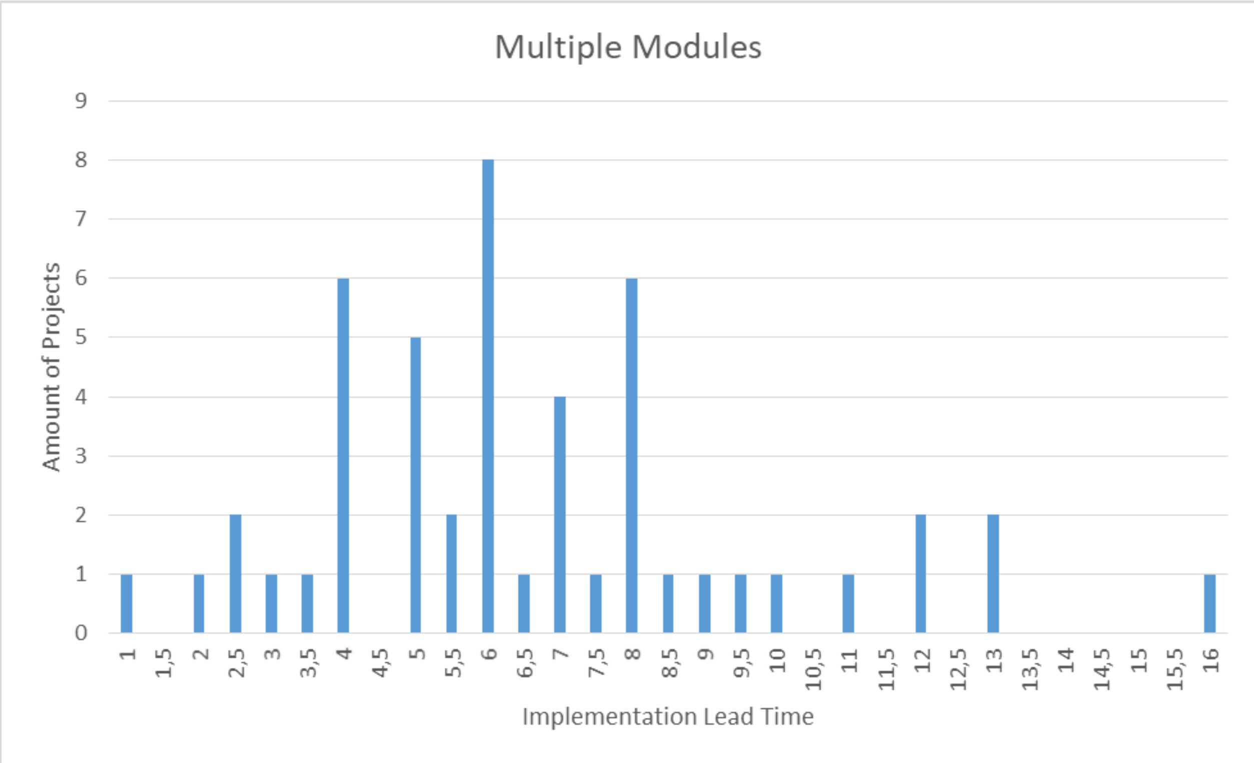
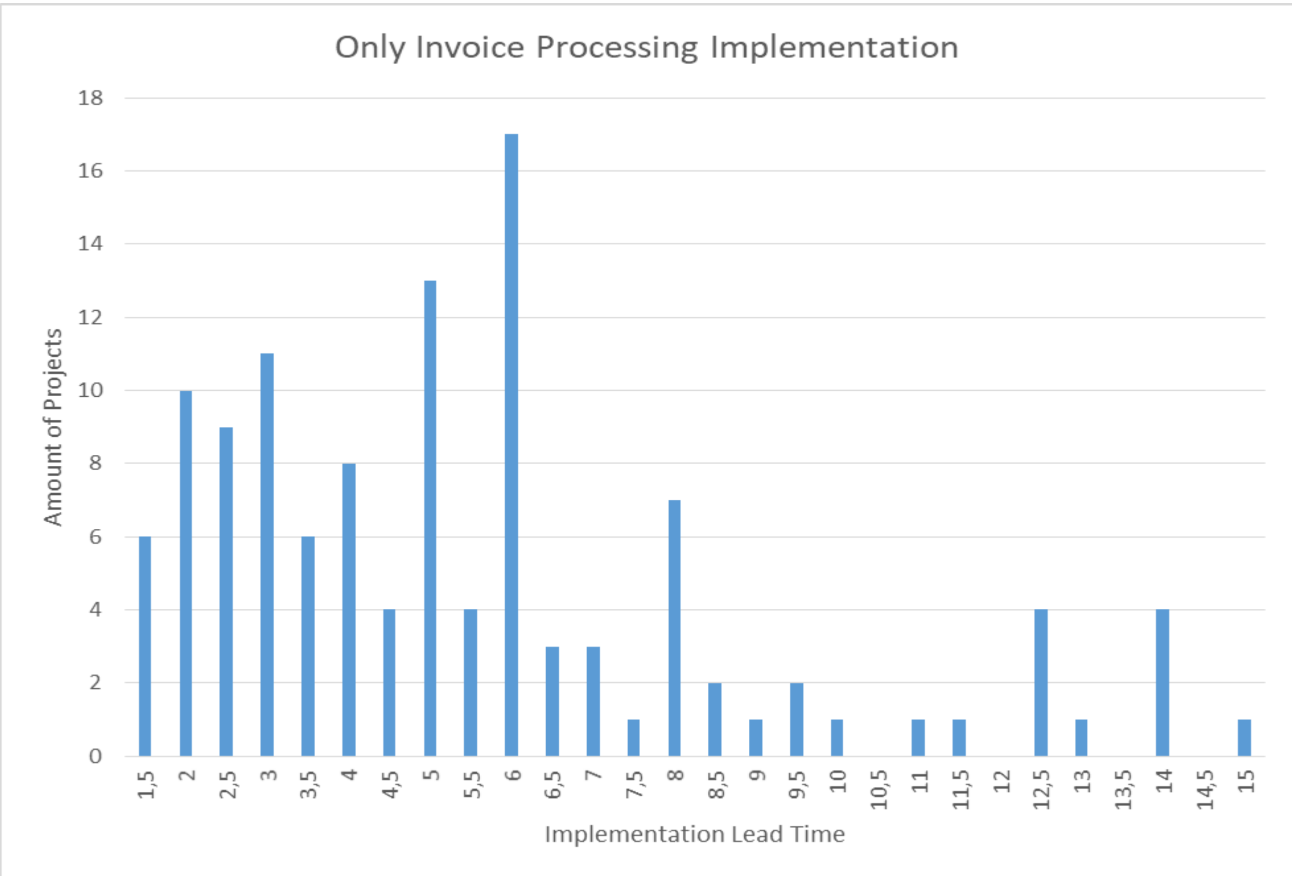


Figure 23: Only Invoice Processing Implementation Data Distribution



The dataset contained 119 projects where only the invoice processing module was being implemented at the same time. The implementation lead time mean of the dataset where only these type of projects are included is equal to 5.52 months.

The dataset contained 49 projects where next to the invoice processing module, at least one other module was being implemented at the same time. The implementation lead time mean of the dataset where only these type of projects are included is equal to 6.66 months.

This analysis implies trying to implement multiple modules at the same time causes a higher average lead time in the implementation of one single module.

Table 8 gives a summarized overview of the average implementation lead times of the different groups. The groups that are related to each other are marked in the same colour.

Table 8: Aspects of the different groups

Group	**Amount of Projects**	**Average Lead Time**
Projects with an end date in January	18	4.86
Projects with an end date in February	30	4.57
Projects with an end date in March	17	6.44
Projects with an end date in April	14	5.46
Projects with an end date in May	10	7.05
Projects with an end date in June	8	6.19
Projects with an end date in July	19	7.08
Projects with an end date in August	10	6.35
Projects with an end date in September	11	6.86
Projects with an end date in October	10	5.80
Projects with an end date in November	12	4.83
Projects with an end date in December	9	7.00
Projects with customers that operate in the education industry	57	4.70
Projects with customers that operate in the healthcare industry	47	6.15
Projects with customers that operate in the non-profit industry	20	6.23
Projects with customers that operate in the business services industry	44	6.85
Projects with a deadline close to new year’s eve (1 month margin)	44	5.07
Projects without a deadline close to new year’s eve (1 month margin)	124	6.13
Projects where only the invoice processing module was being implemented	119	5.52
Projects where multiple modules were implemented at the same time	49	6.66

5.1.3.2 Interviews

As mentioned earlier, next to collecting missing data, the interviews were also used to derive case specific elements. In every different interview, it was investigated how every different step in the implementation process was handled by both the customer and ProActive. Every different interviewee approached the implementation process in a different way. This made it possible to see what approach had what impact on the implementation lead time. The interviews are all summarized in Appendix V.

No interviewee mentioned a company specific factor that was not found in the theoretical framework. Three factors that influence the implementation lead time came forward in all interviews as the most important ones:

- Having the *customer's expectations* in line with what the supplier has in mind is crucial for the implementation lead time, according to the interviewees. The two respondents with a relatively high implementation lead time both stated they expected other things from both the system and the division of roles in the implementation project than how this eventually turned out to be in reality. Furthermore, the two respondents with an average lead time both had a small difference in expectations and what was required for the project[51]. Lastly, the two projects with a relatively short lead time stated that all expectations were met. This is in line with what was found in the literature model, since this factor is also in the top five most important factors in the literature model.

- The *customer's preparation for the project* also came forward as an important factor that influences the average implementation lead time. The two respondents that had a relatively long lead time both stated that they did not really prepare requirements for their projects: one of them chose for ProActive because they were the quickest to respond and the other one went for ProActive without preparation because a partner of them advised them to. The other four interviewees on the other hand were able to explain in detail why they went for ProActive and how they prepared for the implementation. This factor did not feature in the top five most important factors of the literature model. Therefore, it is expected this factor has a bigger impact in the context of ProActive.

- The *project management* of the implementation also came forward in every interview as an important factor that influences the implementation lead time. The two respondents with a relatively long lead time both stated that at the time of the implementation no one in their organization had the experience to sufficiently manage the project and they both expected that ProActive would manage the project for them, which eventually turned out not to be the case. The other four respondents on the other hand had a project manager that was experienced with similar implementations at the time of the implementation, and took the initiative the manage the project by themselves. This is also in line with what was found in the literature model, as this factor is also in the top five most important factors in the literature model.

[51] One with the external project manager, and one with the special department.

Another interesting finding that came forward from the interviews is that every interviewee mentioned that the training was good, but had a low impact on the eventual implementation lead time, because they claimed that the only way to get used to the new system was to "just start working with the system" in the pilot-phase. This is also one of the reasons the factor '*training and education'* was discarded in sub-section 4.2.2.3.

5.2 Hypothesis Testing

In this section, several hypotheses will be formulated based on the theoretical framework, the explorative dataset analysis, and the interviews. Firstly, the preliminaries will be discussed. Hereby, the different statistical testing methods that will be used are explored. Subsequently, the testing results are be described.

5.2.1 Preliminaries

In this sub-section, the different statistical testing methods that will be used will be discussed. For every different testing method, it will be described how the test works, what the null hypothesis[52] (H0) and the alternative hypothesis[53] (Ha) are, how the test statistic is calculated, when H0 is rejected, and what the test assumptions are.

Test of Normality: Kolmogorov-Smirnov

This method tests the normality of a dataset by testing if a variable follows a given distribution in a population.

- *Null hypothesis:* The data is normally distributed.
- *Alternative hypothesis:* The data is not normally distributed.
- *Formula: Dn = sup* | *Fn(x) – F(x)*|, where Dn is the test statistic, and "*sup* | *Fn(x) – F(x)*|*"* represents the largest difference between the tested distribution and a standard normal distribution.
- *Reject Criteria:* H0 can be rejected at $p < 0.05$.
- *Assumptions:* The sample size is $N < 30$. When a sample of $N > 30$ is available for testing, based on the *central limit theorem*[54], it can be assumed that the distribution of the sample means are approximately normally distributed (Mordkoff, 2016). When this is the case, parametric testing methods can be applied (Mordkoff, 2016). Therefore, Kolmogorov-Smirnov is only used in this chapter for groups with a sample size of $N < 30$.

Two-Independent Sample T-Test

Executing the two-sample t-test returns a p-value, which can be used to assess if the means of two groups are significantly different to each other, or not.

- *Null hypothesis:* The means of the two compared groups are significantly equal to each other.

[52] The null hypothesis claims there is no significant difference between the different groups of data.
[53] The alternative hypothesis claims there is a significant difference between the different groups of data.
[54] The central limit theorem states a group of data with a higher N has a distribution of the sample mean that is closer to normality than a group of data with a lower N, regardless of how the data distribution looks like. Hereby, a general rule of thumb is it can safely be assumed the sampling distribution of the mean is normal when N > 30.

- *Alternative hypothesis:* The means of the two compared groups are significantly different to each other.
- *Formula: $t = (\dot{x}1 - \dot{x}2) / \sqrt{((S1/N1) - (S2/N2))}$,* where t is the test statistic, ẋ1 is the mean of group 1, ẋ2 is the mean of group 2, S1 is the standard deviation of group 1, N1 is the amount of cases in group 1, S2 is the standard deviation of group 2, and N2 is the amount of cases in group 2.
- *Reject Criteria:* H0 can be rejected at $p < 0.05$.
- *Assumptions:* There are two independently sampled groups, the population of both groups is normally distributed, both groups consist of at least five rows of data, and the dependent variable is continuous. (Rasch et al, 2007).

One-Way ANOVA Test
This test returns a p-value, which shows whether there is a significant difference between at least one pair of three or more different groups.

- *Null hypothesis:* The means of all compared groups are significantly equal to each other.
- *Alternative hypothesis:* The means of at least one pair of the different groups are significantly different.
- *Formula: $F = MST / MSE$,* where F is the test statistic, MST is the variance *between* the different groups, and MSE is the variance *within* the different groups.
- *Reject Criteria:* H0 can be rejected at $p < 0.05$.
- *Assumptions:* There are three or more independently sampled groups, the population of all groups is normally distributed, each group consists of at least five rows of data, and the dependent variable is continuous (Kim, 2017).

5.2.2 Test Results

In this sub-section, for every hypothesis, it will be described where it is based on[55], to what factor(s) the hypothesis is related, and what the testing results are.

The hypotheses that will be tested with the complete sample set are separated from the hypotheses that will be tested on the basis of the interview- and survey subset. Also, the hypotheses that were tested with the same statistical testing method will be grouped together.
The hypotheses will be tested by dividing the sample set related to a specific hypothesis into different groups, and then testing the significance of the difference in average implementation lead times between those different groups.
After the hypothesis tests, it will also be discussed what factors were not tested, and why.

At the end of this section, a summarized overview of the testing results will be provided in table 11. On the basis of this overview, a qualitative model of lead time distribution will be created for ProActive.

[55] Theoretical framework, Exploratory Analysis of the Complete Sample Set, or the Interviews

5.2.2.1 Complete Sample Set Two-Sample T-Tests

The two-sample t-test is a parametric testing method. Therefore, first the normality of the different groups of the complete sample set that were being compared to only one other group and had a N < 30 was assessed.
Every different group from the complete sample set that was compared to one other group had a sample size of at least 30 cases, except for the group of projects where a connection with a customer's financial system had to be made for the first time. Therefore, only the normality of this group of projects was tested. For the other groups, with the central limit theorem in mind, it was assumed a parametric testing method could be applied. The test of the 'new connection group' resulted in a p-value of 0.062197, which is higher than 0.05, which indicates a high chance that the data is normally distributed. Therefore, for every different group from the complete sample set, a parametric testing method was used.
As mentioned before, the two-sample t-test was used for all hypotheses where only two groups of data were compared to each other. For the complete sample set, this was the case for hypotheses 1, 2, 3, 4, and 5.

In the theoretical framework, several causalities between different factors and the implementation lead time were found. Hereby, it was also found if a specific factor has an increasing- or a decreasing impact on the implementation lead time. However, important to note is that the two-sample t-test cannot be used to test whether a specific factor is significantly correlated with the implementation lead time or not. The test only shows if the two tested groups are significantly different to each other. Therefore, for almost all hypotheses, it will be assumed how a specific factor influences the average implementation lead time[56] is the same as described in the theoretical framework when the null hypothesis related to that factor is rejected. For the other hypotheses, that were based on the exploratory analysis of data, it will be assumed how a specific factor influences the average lead time is the same as the data indicates[57]. For this reason, all hypothesis tests will be one-tailed, because a one-tailed test examines if there is a significant difference between the two different tested groups in a specific direction.

Hypothesis 1: Customization (New Connection)

This hypothesis came forward from the theoretical framework, because several papers rated the factor 'customization' as the most important.
Since ProActive is a software package supplier, they choose to avoid customization as much as possible, but in some implementation projects, customization is necessary. As described in section 3.1, this is the case when the financial system where the customer works with before the implementation with ProActive is a system that is unknown to ProActive. Therefore, to measure the impact of customization on the average implementation lead time of ProActive, the complete sample set was divided into one group with projects where a connection was required that was

[56] If a specific factor increases, or decreases the average implementation lead time.
[57] For example, the average lead time of projects where multiple modules were implemented at the same time is more than a month longer than the average lead time of projects where only the invoice processing module was implemented at the same time. For this factor it is thus assumed that implementing multiple modules at the same time has an increasing impact on the average implementation lead time.

already familiar to ProActive, and one group where the required connection was new to ProActive.

H0: There is no significant difference in average implementation lead time between implementation projects where customization is required and implementation projects where customization is not required.

Ha: Implementation projects where customization is required have a significantly higher average implementation lead time than implementation projects where customization is not required.

The mean lead time of the eleven projects where a connection was made with a financial system for the first time is 11.50 months (Table 8). This was a strong indication that customization increases the average implementation lead time.

The significance test of these two groups resulted in a p-value of 0.000001. This means the result of this test is significant at $p < 0.05$. This provides good evidence against the *null* hypothesis.

Hypothesis 2: Deadline New Year's Eve (Customer Commitment, Planning)

The factor 'deadline new year's eve' was derived from the exploratory data analysis. Also, in one of the interviews, it was stated that the implementation project was finished very quickly, because they wanted to finish their project before new year's eve. To achieve this goal, they were very committed to the project and had very tight deadlines. Therefore, analysing this hypothesis in the dataset was also a measure of the factors 'customer commitment' and 'project planning' from the theoretical framework, since it was stated that those were the factors that were mainly influenced by having a deadline around new year's eve.

H0: There is no significant difference in average implementation lead time between implementation projects where the planned deadline of the project is within the margin of a month of new year's eve and implementation projects where the planned deadline of the project is outside the margin of a month of new year's eve.

Ha: Implementation projects with a planned deadline within the margin of a month of new year's eve have a significantly lower average implementation lead time than implementation projects that have a planned deadline outside the margin of a month of new year's eve.

The mean lead time of projects with a deadline around new year's eve is 5.07, and the mean of the other group of projects without a deadline around new year's eve is 6.13 (Table 8).

The significance test of this hypothesis resulted in a p-value of 0.003934. This means the result of this test is significant at $p < 0.05$. This provides good evidence against the *null* hypothesis.

Hypothesis 3: Multiple Module Implementations (Resource Allocation)

The factor 'multiple modules' was derived from the exploratory data analysis. Also, one of ProActive's consultants stated in an interview that customers have a harder time efficiently allocating their resources when implementing multiple modules at the same time. Furthermore, in literature it is supported that having to focus on multiple projects at the same time makes it more difficult for a customer to efficiently allocate their resources (Patanakul et al, 2009). For example, Patanakul et al (2009) describes required resources might not be available for one project because they are already in use for another project. Analysing this hypothesis in the dataset was thus also a measure of the factor 'resource allocation' from the theoretical framework.

H0: There is no significant difference in average implementation lead time between implementation projects of a single module where at the same time at least one other module was being implemented and implementation projects of the same module where no other modules were being implemented at the same time.

Ha: Implementation projects where only one module is being implemented at the same time have a significantly lower average implementation lead time than implementation projects where next to that implementation project, at least one other module is being implemented at the same time.

The mean lead time of projects where only the invoice processing module was implemented at the same time is 5.52, and the mean of the other group of projects, with more than one module being implemented at the same time, is 6.66 (Table 8).

The significance test of this hypothesis resulted in a p-value of 0.007641. This means the result of this test is significant at $p < 0.05$. This provides good evidence against the *null* hypothesis.

Hypothesis 4: Consultant's Level of Assistance

This factor was operationalized as the consultant's experience in section 4.1. Also, as Morrison et al (1992) states, it takes time to get used to a new job (like the job of a consultant), which means the consultant's level of assistance is not as optimal as it could be in the first few months of employment. Therefore, the impact of this factor on the average implementation lead time was tested by dividing the dataset into one group where the assigned consultant to the projects had less than six months of employment at ProActive, and one group where the assigned consultant to the projects had more than six months of experience at ProActive.

H0: There is no significant difference in average implementation lead time between projects where the assigned consultant had less than six months of experience at ProActive and implementation projects where the assigned consultant had more than six months of employment.

Ha: Implementation projects where the assigned consultant has more than six months of employment at ProActive have a significantly lower average lead time than implementation projects where the assigned consultant has less than six months of employment.

The mean lead time of projects where the assigned consultant was in the first six months of employment at ProActive was 5.76 months (Table 9).

The significance test of this hypothesis resulted in a p-value of 0.465085. This means the result of this test is *not* significant at $p < 0.05$. This provides good evidence to reject the *alternative* hypothesis.

Hypothesis 5: Support Calls (Customer Adaptability)

As was also described in section 4.1, the impact of the factor ‘customer adaptability’ was tested by dividing the dataset into one group with projects that used an above average amount of support within six months after the implementation was finished, and one group with a below amount of support within six months after the implementation was finished.

H0: There is no significant difference in average implementation lead time between implementation projects where the customer used an above average amount of support within six months after the project was finished and projects where the customer used a below average amount of support within six months after the project was finished.

Ha: Implementation projects where the customer used an above average amount of support within six months after the implementation was finished have a significantly higher average lead time than implementation projects where the customer used a below average amount of support within six months after the implementation was finished.

The mean lead time of projects where an above average amount of support was used is 6.17 months. The mean of projects with a below amount of support is 5.72 (Table 9).

The significance test of this hypothesis resulted in a p-value of 0.189977. This means the result of this test is *not* significant at $p < 0.05$. This provides good evidence to reject the *alternative* hypothesis.

5.2.2.2 Complete Sample Set One-Way ANOVA tests

As was also done for the two-sample t-tests, again it was first assessed if a parametric testing method could be used. All different groups had a sample size of $N > 30$, except for the group of projects with a customer from the non-profit industry, all different groups based on the end-date months, the group of projects with the third implementation type, and the group of projects with the fourth implementation type. The groups with a sample size of $N < 30$ were first tested on normality. All these tests of normality returned a p-value of $p > 0.05$ (Appendix IX). Therefore, it was assumed a parametric testing method could be used for the groups related to hypotheses 6, 7, 8, and 9.

The One-Way ANOVA test also assumes normality, but is used to measure three or more independently sampled groups. Therefore, this test was used for hypotheses 6, 7, 8, and 9.

On itself, this test for example does not show whether a bigger implementation size leads to a significantly higher average lead time compared to a smaller implementation

size. However, as was also done for the t-tests, it will be assumed how a specific factor influences the implementation lead time is the same as in the theoretical framework, when the null hypothesis related to that factor is rejected.
This assumption can also be made on the basis of our dataset, since the causalities from the literature model are also confirmed by the dataset. For example, as is shown in table 9, the dataset does indicate that a bigger implementation size and less experience with a customer's industry does lead to a higher average lead time compared to a lower implementation size and more experience with a customer's industry. Therefore, it is assumed a p-value lower than 0.05 means that a bigger implementation size and less experience with a specific type of customer lead to a higher average lead time.

Hypothesis 6: Graduated Scales (Implementation Size)

According to literature, a larger sized implementation[58] should have a higher implementation lead time, compared to a lower sized implementation. As mentioned earlier, ProActive has four different implementation sizes, based on the graduated scale of the implemented module. This test was thus performed by dividing the dataset into four different groups, based on these different implementation sizes.

H0: There is no significant difference between the average implementation lead times of implementation projects with different 'implementation types' based on graduated scale.

Ha: Implementation projects of a higher graduated scale have a significantly higher average implementation lead time compared to implementation projects of a lower graduated scale.

The average implementation lead time of projects with the first implementation type is 5.14. The group with the second implementation type had an average lead time of 6.54. The average lead time of the third group is 5.96. The fourth group has an average lead time of 9.13 months (Table 9).

The significance test of this hypothesis resulted in a p-value of 0.005844. This means the result of this test is significant at $p < 0.05$, which provides good evidence against the *null* hypothesis.

Hypothesis 7: Different Modules (Implementation Size)

According to literature, a larger sized implementation (more/longer activities and/or higher complexity) should have a higher implementation lead time, compared to a lower sized implementation. According to ProActive, the contract-management module is easier to implement than the invoice processing module, and the procurement module is the most complex module to implement. This test was performed by comparing three different groups in the dataset based on implemented module.

H0: There is no significant difference between the average implementation lead times of the different modules that are part of the P2P process.

[58] More/Longer activities, or a higher level of Complexity.

Ha: Implementation projects of modules with a higher level of complexity have a significantly higher average implementation lead time compared to implementation projects with a lower level of complexity

The average implementation lead time of the contract-management implementation projects is 5.15. The invoice-processing module implementations have an average lead time of 5.85 months. The procurement module implementations have an average lead time of 7.13 months (Table 9).

The significance test of this hypothesis resulted in a p-value of 0.021505. This means the result of this test is significant at $p < 0.05$, which provides good evidence against the *null* hypothesis.

Hypothesis 8: Customer Industries (Organizational Fit)

This factor was derived from the exploratory analysis of data. Also, ProActive states their system in general has the best fit with the specific type of customers where they are most experienced with. Furthermore, in literature it is widely supported that the factor 'organizational fit' has a significant impact on the average implementation lead time. For this hypothesis, the dataset was divided into four different groups based on the different industries where ProActive's customers are operating in (Education, Healthcare, Business Services and other Non-Profit), to see how these industries differed in implementation lead time.

H0: There is no significant difference between the average implementation lead times of implementation projects with customers from different industries.

Ha: Implementation projects with customers that operate in an industry where ProActive is more experienced with have a significantly lower average implementation lead time than implementation projects with customers where ProActive has less experience with.

The mean lead time of the projects from the education industry is 4.70. The mean of the projects from the healthcare industry is 6.15. The group with other non-profit cases has a mean of 6.23. The mean of the projects with business services companies is 6.85 (Table 8).

The significance test of this hypothesis resulted in a p-value of 0.003934. This means the result of this test is significant at $p < 0.05$, which provides good evidence against the *null* hypothesis.

Hypothesis 9: End Date Month of Implementations

This hypothesis was based on the exploratory data analysis. The dataset was divided in twelve different groups, based on the months of the year where the end dates of the projects were in.

H0: There is no significant difference between the average implementation lead times of implementation projects that have their end dates in different months of the year.

Ha: Implementation projects that have their deadlines in the middle of the year (May, June, July) have a significantly higher average lead time than implementation projects *that have their deadlines at the beginning or end of the year (January, February, March, October, November, December)*

The significance test of this hypothesis resulted in a p-value of 0.058315. This means the result of this test is *not* significant at $p < 0.05$, which provides good evidence to reject the *alternative* hypothesis.

The above mentioned hypothesis tests show whether the presence of a specific factor leads to a higher or lower average lead time, or if the presence of a specific factor does not lead to a significantly different lead time. However, the tests do not show how much a specific factor impacts the lead time.
Table 9 gives an overview of the average implementation lead times of the different groups that were analysed based on the operationalization in section 4.1[59]. The groups that were compared to each other are marked in the same colour. This table can be used to get an indication of the impact of a specific factor on the lead time. The exact impact will later in this chapter be quantified.

Table 9: Aspects of the different groups from the complete sample set.

Group	***Amount of Projects***	***Mean***
First time connection with customer's financial system	11	11.50
Existing connection with customer's financial system	157	5.46
Assigned consultant with less than half a year of employment at ProActive	53	5.76
Assigned consultant with more than half a year of employment at ProActive	115	5.89
Projects with an above average amount of support used within six months of the end date of the implementation	46	6.17
Projects with a below average amount of support used within six months of the end date of the implementation	122	5.72
Projects where the first implementation type based on graduated scale was applicable	85	5.14
Projects where the second implementation type based on graduated scale was applicable	66	6.54
Projects where the third implementation type based on graduated scale was applicable	13	5.96
Projects where the fourth implementation type based on graduated scale was applicable	4	9.13
Invoice-processing module implementations	168	5.85
Procurement-module implementations	32	7.13
Contract-management module	34	5.15

[59] The average lead times of the different groups from the exploratory analysis are already mentioned in table 8.

implementations		

5.2.2.3 Sub-Sample Set Two-Sample T-Tests

Firstly, the normality of the different groups in the sub-sample set was tested by using the Kolmogorov-Smirnov-method at $p < 0.05$. The reason for this is that none of the groups from the sub-sample set had a size of at least 30 cases, which means the central limit theorem does not apply for these groups. All normality tests of the different groups returned a p-value higher than 0.05 (table 10), which means there is good evidence the sub-sample set groups are normally distributed. Therefore, again a parametric testing method was used.

The Two-Sample t-test or the One-Way ANOVA test were again the most sufficient possible testing methods, because of the normal data distribution in the sub-sample set. The responses to the survey questions related to these factors were either “Disagree”, “Neutral”, “Agree”, or “Strongly Agree”. Dividing the sub-sample set into four different groups based on these four different possible responses would make the One-Way ANOVA method the most sufficient testing method. However, for the One-Way ANOVA test to return useful results, every different group needs to have at least five rows of data (Kim, 2017). Because of the small sub-sample set size, it was therefore not possible to test the hypotheses related to the sub-sample set with One-Way ANOVA.

Therefore, hypotheses 10, 11, 12, 13, and 14 that are mentioned below were all tested with the Two-Sample T-Test. However, as mentioned before, the Two-Sample T-Test can only be performed when comparing two independently sampled groups. Therefore, for every different hypothesis, the sub-sample set was divided into one group where the survey response related to the specific hypothesis was “Agree” or “Strongly Agree”, and one group where the survey response was “Neutral” or “Disagree”. According to Liu et al (2017), dealing with the survey responses like this should not affect the reliability of the testing results, because in this way the extreme response bias[60] is also dealt with. Some survey respondents might fill in “Strongly Agree” when they more have the feeling of “Agree” because of this extreme response bias (Liu et al, 2017). Liu et al (2017) mentions this also works the other way around: some survey respondents might fill in “Agree” instead of “Strongly Agree”, because they want to avoid extreme answers. For this reason, a survey response of “Agree” should have meaning similar to a survey response of “Strongly Agree’. This makes it acceptable to divide the sub-sample set into one group with “Agree” and “Strongly Agree”, and one group with “Neutral” and “Disagree, and to compare these two different groups with each other.

How the factors related to hypotheses 10, 11, 12, 13, and 14 were derived from the interviews and surveys is mentioned in sub-section 4.2.2.2.

Hypothesis 10: Customer Expectations

The factor *‘customer expectations’* came forward as one of the most important factors that influence implementation lead time in both the theoretical framework and the interviews. The sub-sample set was divided into one group where the customer’s

[60] When the respondent gives extreme answers, even if they do not have an extreme view (SurveyMethods, 2014).

expectations were in line[61] with what ProActive had in mind based on the interviews and surveys, and one group where the customer's expectations were not in line[62].

H0: There is no significant difference in average implementation lead time between implementation projects where the customer's expectations about the product and the division of roles in the project are in line with what the supplier has in mind and projects where the customer's expectations are not completely in line.

Ha: Implementation projects where the customer's expectations about the product and the division of roles in the project are in line with what the supplier has in mind have a significantly lower average lead time than implementation projects where the customer's expectations are not completely in line.

The significance test of this hypothesis resulted in a p-value of 0.001354. This means the result of this test is significant at $p < 0.05$, which provides good evidence that the *null* hypothesis can be rejected.

Hypothesis 11: Customer Skills

This hypothesis came forward as important in both the interviews and the theoretical framework. The sub-sample set was divided into one group where the customer did not have sufficient IT knowledge, and one group where the customer did have sufficient IT knowledge.

H0: There is no significant difference in average implementation lead time between implementation projects where the customer's employees have a high level of IT knowledge compared to implementation projects where the customer's employees have a lower level of IT knowledge.

Ha: Implementation projects where the customer's employees have a high level of IT knowledge have a significantly lower average implementation lead time compared to implementation projects where the customer's employees have lower levels of IT knowledge.

The significance test of this hypothesis resulted in a p-value of 0.145319. This means the result of this test is *not* significant at $p < 0.05$, which provides good evidence to reject the *alternative* hypothesis.

Hypothesis 12: Customer Experience with Similar Implementations

This hypothesis came forward as important in both the interviews and the theoretical framework. The sub-sample set was divided into one group where the customer did not have experience with similar implementations, and one group where the customer did have experience with similar implementations.

H0: There is no significant difference in average implementation lead time between implementation projects where the customer is experienced with similar

[61] A survey response of "Agree" or "Strongly Agree".
[62] A survey response of "Disagree" or "Neutral".

implementations compared to implementation projects where the customer has no experience with similar implementations.

Ha: Implementation projects where the customer is experienced with similar implementations have a significantly lower average implementation lead time than implementation projects where the customer has no experience with similar implementations.

The significance test of this hypothesis resulted in a p-value of 0.06989. This means the result of this test is *not* significant at $p < 0.05$, which provides good evidence to reject the *alternative* hypothesis.

Hypothesis 13: Resource Allocation

This factor came forward as important in the theoretical framework, exploratory data analysis, and the interviews. The sub-sample set was divided into one group where the customer did sufficiently allocate their resources, and one group where the customer did not sufficiently allocate their resources.

H0: There is no significant difference in average implementation lead time between implementation projects where the customer sufficiently allocated their resources compared to implementation projects where the customer did not sufficiently allocate their resources.

Ha: Implementation projects where the customer sufficiently allocated their resources have a significantly lower average implementation lead time than implementation projects where the customer did not sufficiently allocate their resources.

The significance test of this hypothesis resulted in a p-value of 0.015912. This means the result of this test is significant at $p < 0.05$, which provides good evidence that the *null* hypothesis can be rejected.

Hypothesis 14: Prototype

In both the interviews and existing literature, it was claimed that the presence of a prototype should result in a lower average implementation lead time. The sub-sample set was divided into one group where the customer claimed that they had no prototype available, and one group where the customer claimed that they did have a prototype available.

H0: There is no significant difference in average implementation lead time between implementation projects where the customer had a prototype available and implementation projects where the customer did not have a prototype available.

Ha: Implementation projects where the customer had a prototype available have a significantly lower average implementation lead time than implementation projects where the customer did not have a prototype available.

The significance test of this hypothesis resulted in a p-value of 0.350131. This means the result of this test is *not* significant at $p < 0.05$, which provides good evidence to reject the *alternative* hypothesis.

Table 10 gives an overview of the average implementation lead times of the different groups that were analysed based on the interview- and survey sub-sample set. The groups that were compared to each other are marked in the same colour.

Table 10: Aspects of the different groups of the interview-and survey sub-sample set

Group	**Amount of Projects**	**Mean**	**Kolmogorov-Smirnov p-value**
Customer Expectations Agree of Strongly Agree	14	5.96	0.87981
Customer Expectations Neutral or Disagree	9	7.89	0.27625
Customer Skills Sufficient	14	6.75	0.20981
Customer Skills Insufficient	9	6.67	0.74518
Customer Experience Yes	14	5.14	0.20672
Customer Experience No	9	9.17	0.84721
Resource Allocation Agree or Strongly Agree	13	4.58	0.07957
Resource Allocation Neutral or Disagree	10	9.5	0.24582
Prototype Available	17	6.47	0.76368
Prototype not Available	6	7.42	0.19162

5.2.3 Qualitative Model of Lead Time Distribution

Table 11 gives an overview of the results of this section. The two factors that were described in section 4.2 as factors with limited data were not tested because of a lack of variety in interview- and survey responses[63]. The three discarded factors from section 4.2 were also not tested.

Table 11: Hypothesis Testing Results

Accepted Hypotheses	**Rejected Hypotheses**	**Untested Factors**
Customization (#1)	Consultant's Experience (#4)	Top Management Support
Deadline New Year's Eve (#2)	Support Calls (#5)	User Training & Education
Multiple Modules (#3)	End Date Month (#9)	Product Quality
Graduated Scales (#6)	Customer Skills (#11)	Project Management
Different Modules (#7)	Customer Experience (#12)	Customer Preparation
Different Industries (#8)	Prototype Available (#14)	
Customer Expectations (#10)		

[63] Only two respondents stated (indirectly) they insufficiently prepared their requirements, and only three respondents stated their project manager was insufficient. For a reliable hypothesis test, at least five rows of data need to be available in each group (Kim, 2017).

Resource Allocation (#13)		

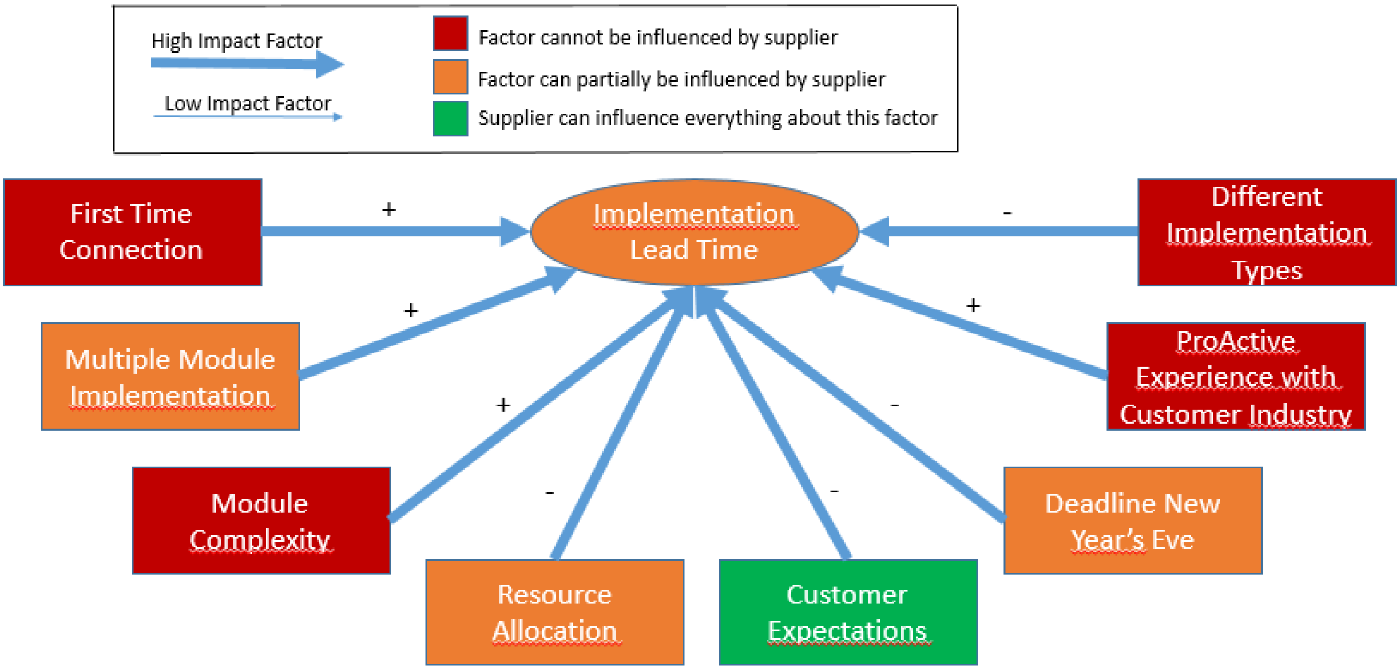
On the basis of the theoretical framework, the exploratory data analysis, and the interviews, it was expected the factors '*Consultant's Experience', 'Support Calls',* and '*Customer Skills & Experience'* would be significant influencing factors of implementation lead time. The theoretical framework underlined the importance of the consultant's level of assistance and the customer's adaptability, whereas the factor '*Customer Skills & Experience'* mainly came forward from the interviews as one of the most important factors. However, in section 3.3 it was noted that in the ASP implementation process the role of the consultant is bigger than in ProActive's implementation process. It is interesting to see that this relatively smaller role of ProActive's consultant is also confirmed by the hypothesis testing results.

On the other hand, after comparing the two processes, it was also expected that the impact of the customer's skills and experience are more significant in ProActive's implementation process than in the implementation of an ASP. It was thus surprising that there was no significant evidence to accept the alternative hypotheses related to these factors.

Lastly, based on the ASP- and ProActive's process comparison, it was expected that the factors '*customization*' and '*customer's expectations*' have a significant impact on the implementation lead time. It was also interesting to see that this was confirmed by the hypotheses testing results.

The accepted hypotheses form the basis for the qualitative model of lead time distribution at ProActive. This model is shown in Figure 24.

Figure 24: Qualitative Model of Lead Time Distribution at ProActive



5.3 Quantitative Model of Lead Time Distribution

The results from the previous section show that the accepted hypotheses are the most important factors that influence ProActive's implementation lead time, which partially provides an answer to SQ 4: *"What are the most important factors that influence ProActive's implementation lead time?"*. However, we still do not know *with what impact* these factors influence the implementation lead time. This section follows up on the hypothesis tests by quantifying the impact of the different factors, to provide a complete answer to SQ 4, and to answer SQ 5.

One condition that has to be met before the impact of the different factors can be quantified is that no *multicollinearity*[64] occurs in the dataset. Therefore, this section will start off by detecting and dealing with cases of multicollinearity in the dataset. Hereafter, the quantification of the impact of the different factors will be done by applying machine learning regression on both the complete sample set and the interview & survey sub-sample set. This quantification will consist of the relative importance of the different factors (SQ 4) and a predictive regression model (SQ 5).

In these analyses, the factors related to the rejected hypotheses will also still be taken into account, to see if the relative importance that is returned by the regression model is in line with the results from the previous section.

5.3.1 Dealing with Multicollinearity: Spearman Correlation

The impact of the different factors on the implementation lead time will be measured on the basis of the *random forest* method. This random forest is an algorithm that can be used for machine learning regression, to accurately predict the impact of different independent variables on a dependent variable, which in this case is the impact of the different factors on the implementation lead time. However, one condition for the random forest to return reliable results is that no multicollinearity occurs in the dataset. Multicollinearity could cause problems, because a high correlation between two independent variables could lead to a lower accuracy in regression analysis results (Slinker et al, 1985). An example of a way to deal with multicollinearity is to exclude the cases where it occurs from the dataset, to ensure that the impact of the different factors on the implementation lead time is reliably measured (Slinker et al, 1985).

The random forest results will be covered later in this section, because first we have to deal with multicollinearity. In figure 5 from the literature model, factors that potentially suffer from multicollinearity were already detected. However, the multicollinearity between these factors was rather qualitative, whereas quantifying the multicollinearity between the different factors would open up the opportunity to see exactly what factors have to be excluded from the random forest for it to return reliable results. Therefore, the multicollinearity between the different factors was quantified by calculating the '*Spearman Correlation Coefficient' (R)*.

Zar (2005) describes the '*Spearman Correlation Coefficient'* represents the strength of the correlation between two compared ordinal variables. The R-value is always between -

[64] Multicollinearity: The occurrence of a high correlation between two or more independent variables (Alin, 2010).

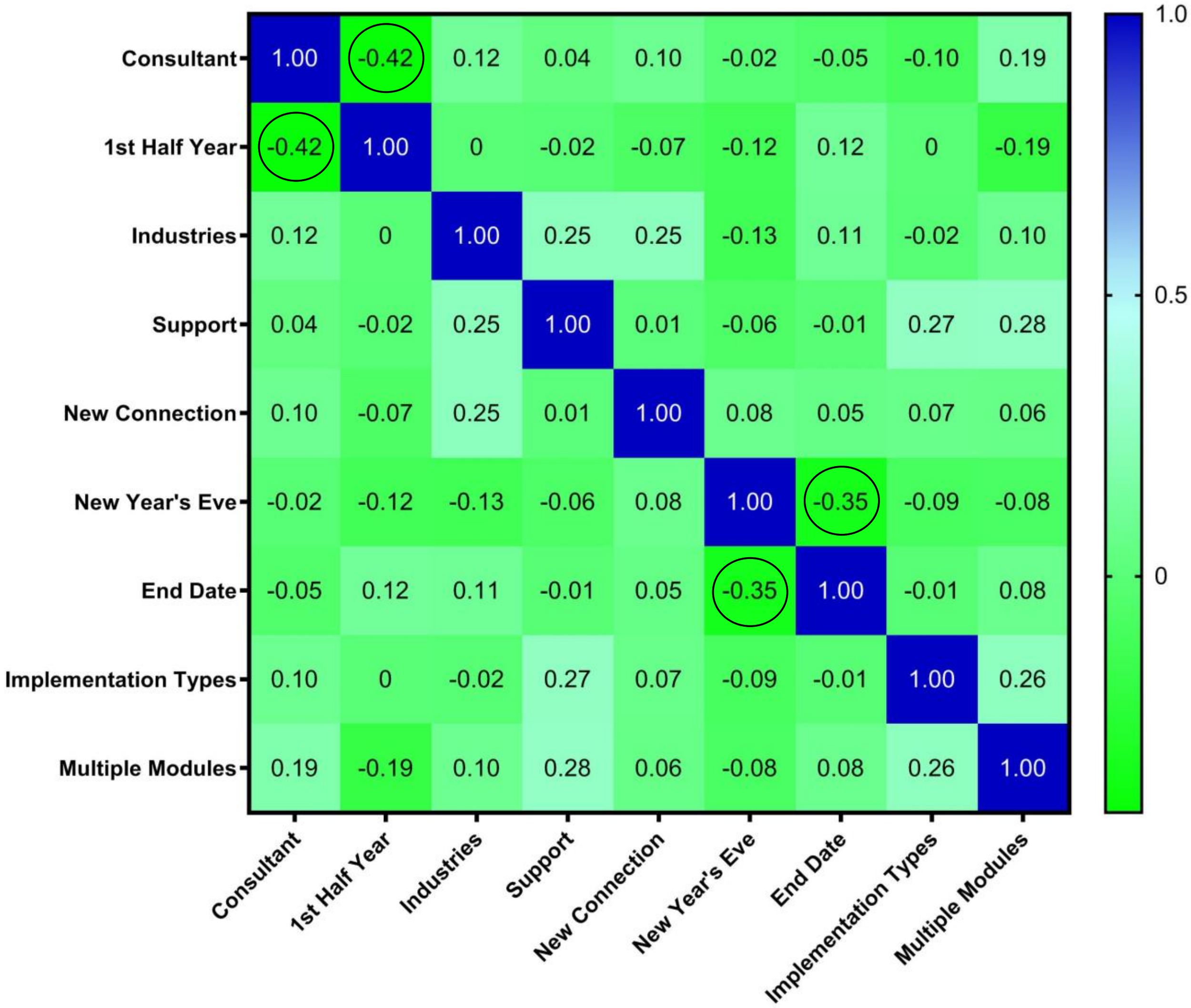
1.00 and 1.00, where 1.00 is a perfect positive correlation and -1.00 represents a perfect negative correlation (Zar, 2005). Since ordinal variables are required, first the independent variables were converted to ordinal data: the independent variables that had two different groups of data were ordered in such a way that the group with an expected decreasing influence on the average implementation lead time was ranked with a 1, and the group with an expected increasing influence on the average implementation lead time was ranked with a 2. This expected influence was based on the hypotheses. For example: the group of projects where a new connection with a customer's financial system was required was ranked with a 2, whereas the opposing group where the connection was already familiar to ProActive was ranked with a 1. Furthermore, the independent variables that had more than two different groups of data were also ordered:

- The different industries were ordered based on the experience ProActive has with a specific industry. In this way, the Spearman correlation coefficient represented in what way more experience with a specific industry correlates with the other independent variables.
- The different implementation types were ordered based on the size of the implementation. In this way, the Spearman correlation coefficient represented in what way a larger implementation size correlates with the other independent variables.
- The different consultants were ordered from most experienced to least experienced. In this way, the Spearman correlation coefficient represented in what way more relevant working experience correlates with the other independent variables.

5.3.1.1 Complete Sample Set Spearman Correlation

Figure 25 shows the R-values of the different inter-correlations between the different independent variables. As mentioned before, the factors from the complete sample set are the factors that were operationalized in section 4.1, and the company specific factors.

Figure 25: Complete Sample Set Spearman Correlation Matrix



This leaves us with the question: when do we deem a correlation to be significant? Zar (2005) describes the p-value depends on the amount of cases (N) in the dataset. The p-values of the different variables were derived from Zar's significance table (2005). This showed that a Spearman correlation coefficient with a sample set of N = 168 is significant when $R > 0.28$ or $R < -0.28$ at $p < 0.05$. Based on this, figure 25 shows two cases of multicollinearity:

- Consultant's Experience & Consultant's First Half Year. This could have been expected, because consultants with less experience are more likely to have projects where they were in the first half year of service at ProActive, whereas the most experienced consultants are less likely to be in the first half year of service in the projects in the dataset.
- End Date Month & New Year's Eve. This could also have been expected, because New Year's Eve is about projects with an End Date Month in either December or January.

Based on Slinker et al (1985), to deal with these cases of multicollinearity, the factors that caused the multicollinearity were omitted from the dataset. This means the factors 'Consultant's Experience' and 'End Date Month' were left out of the Random Forest algorithm. The factor ‘Consultant’s Experience’ was left out instead of the factor ‘Consultant’s First Half Year’, because some consultants were assigned to only one or two projects in the dataset, which means it is more likely the implementation lead times of those projects were an incident. The factor ‘End Date Month’ was left out instead of the factor ‘New Year’s Eve’, because the factor ‘New Year’s Eve’ specifically compares the months where it is expected to have a lower lead time, whereas for the factor ‘End Date Month’ it is more difficult to transfer the data to ordinal data.

5.3.1.2 Interview & Survey Sub-Sample Set Spearman Correlation

Zar’s significance table (2005) was again used to determine when the R-value of a factor in the sub-sample set was significant. This showed that the Spearman Correlation Coefficient on a sample set with N = 23 is significant when $R > 0.49$ or $R < -0.49$ at $p < 0.05$. Figure 26 shows the R-values of the different inter-correlations between the independent variables from the sub-sample set. Hereby, the factors with limited data from section 4.2[65] are also taken into account, because this helps in analysing the interdependencies between the different independent variables.

Figure 26: Interview/Survey Sub-set Correlation Matrix

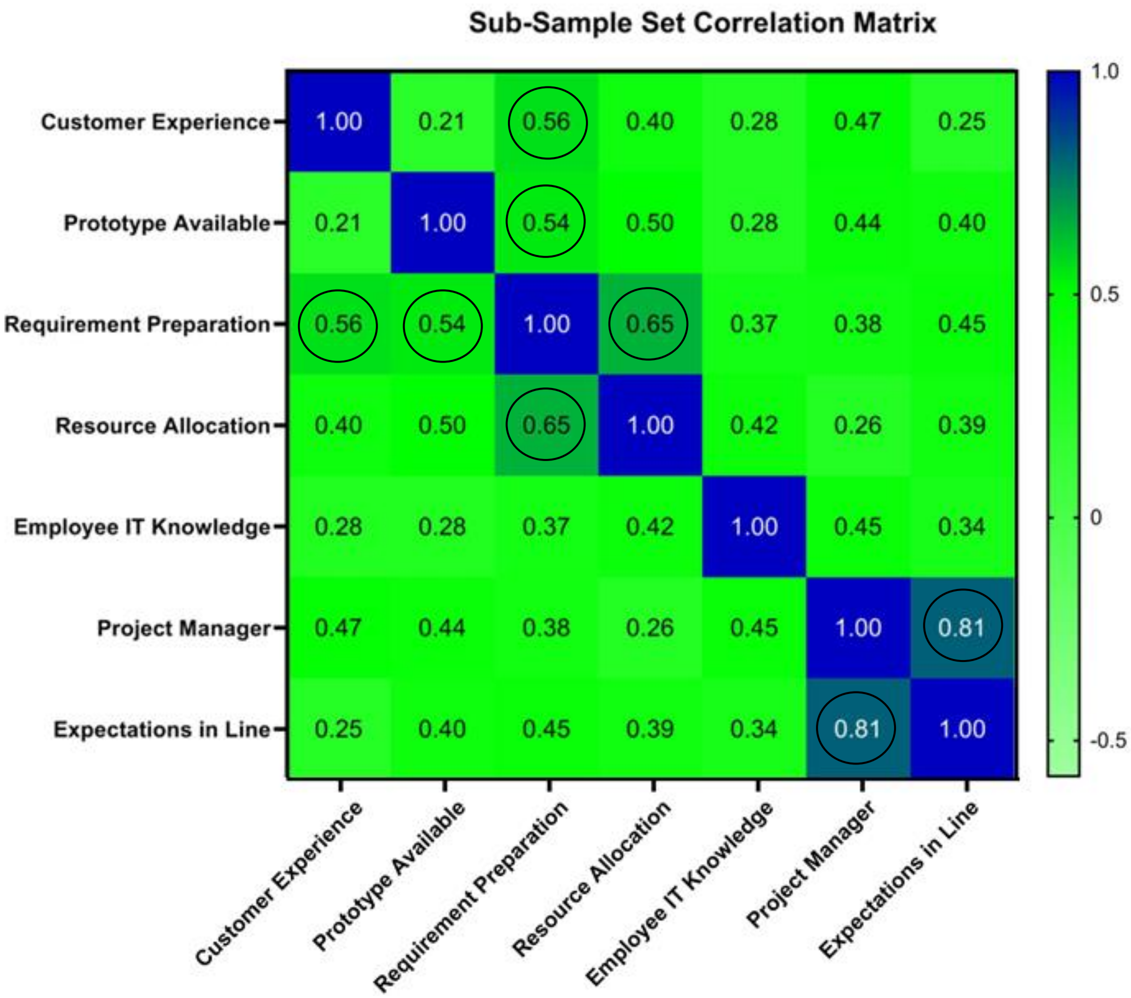


Figure 26 shows several correlation coefficients above 0.49 or below -0.49. As mentioned before, this is when multicollinearity occurs, which means, according to

[65] The factors ‘Project Manager’ and ‘Requirement Preparation’.

Slinker et al (1985), some of the factors have to be excluded from the dataset in able to reliably perform the Random Forest test. The factors that were omitted from the dataset for the Random Forest regression are the following:

- The factors '*Requirement Preparation'* and *'Project Manager'* were omitted, because as mentioned before, these factors are prone to the response bias and therefore lead to less reliable results.
- The factor *'Prototype Available'* was omitted from the set because this factor is highly correlated with the factor '*Resource Allocation*'. Also, as Petter (2008) also stated, this factor is mainly used to efficiently manage customer expectations, and the influence of the factor '*Expectations in Line'* is still covered in the forest in this way.

5.3.2 Machine Learning: Random Forest

Now that we have dealt with multicollinearity, it is possible to quantify the impact of the different factors. As mentioned before, this will be done on the basis of random forest.

5.3.2.1 Preliminaries

Random forest is an algorithm that uses randomly generated decision trees which are averaged to calculate a prediction with a low error (James et al, 2013). Donges (2019) describes random forest as a very easy way to measure the relative importance of each feature on the prediction, which in this case is the importance of the different factors that influence the implementation lead time. Measuring the relative importance of the different factors that influence the lead time helps in answering SQ 4, while the predictive regression model the forest returns can be used as a quantitative model of the lead time distribution (SQ 5). This makes random forest well applicable for this research.

James et al (2013) describes regression tree predictions generally have a lower accuracy than other regression techniques. However, James et al (2013) also describes random forest actually increases the predictive performance by randomly selecting a sample of N predictors as split candidates from the full set of predictors. In other words, at each split of the tree, the algorithm does not consider a part of the available predictors (James et al, 2013). This prevents the strong predictors in the forest from dominating the other factors. If the algorithm would consider all available predictors in every split of the tree, this would lead to different decision trees that look very similar to each other. Not considering all available predictors at every split of the tree also prevents the random forest from overfitting (James et al, 2013).

In machine learning one of the main goals is to develop a model with the highest possible predictive accuracy (James et al, 2013). In a random forest, it is important to determine the optimal amount of random predictors[66] that will be used in every tree of the forest and the optimal amount of trees in the forest (James et al, 2013). This optimal combination of random predictors and trees can be determined by looking at what combination leads to the lowest possible Mean Squared Error (MSE) (James et al, 2013). To acquire this optimal amount of random predictors and trees in the forest, a tuning algorithm was used

[66] The amount of randomly selected independent variables that are used for every different tree in the forest.

in R Studio. This algorithm performs an exhaustive search[67] that returns the combination of random predictors and trees that lead to the lowest possible MSE. This tuning algorithm was used for both the complete sample set and the interview/survey sub-sample set. For both sets of data, it will first be described what the optimal combination of random predictors and trees was according to the tuning algorithm. The MSE of the prediction will be discussed in the evaluation of the model.

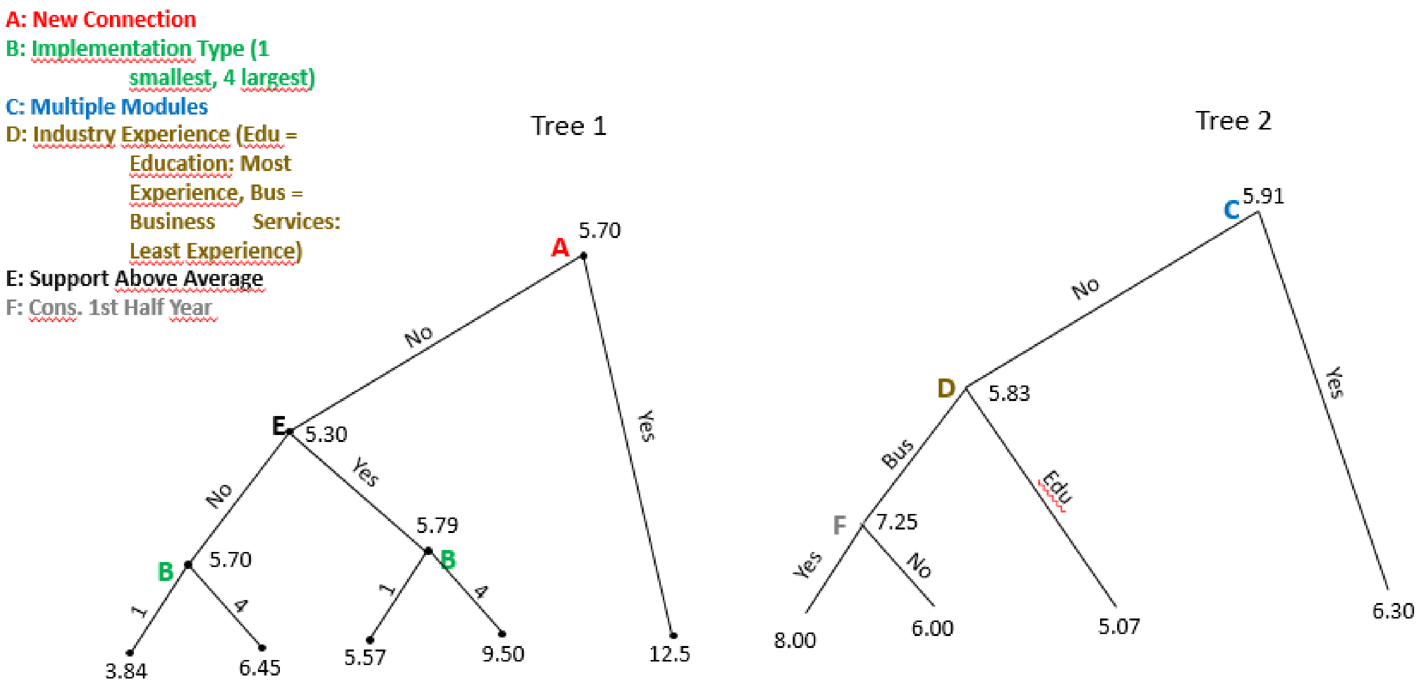
5.3.2.2 Complete Sample Set Random Forest

The random forest regression model was trained with the following R studio command: *tune(randomForest,Lead_Time~.,data=training,test.x = test,importance=TRUE, type="regression",ranges=list("mtry"=seq(1,mtry_max),"ntree"=seq(100,1000,by=100)))*
Hereby, "*mtry_max*" selects the optimal amount of random predictors, and *"ntree"* selects the optimal amount of trees. This showed the combination of three random predictors and 600 trees leads to the lowest possible MSE between the predictions for the test set and the actual values of the test set.

5.3.2.2.1 Quantitative Model of the Lead Time Distribution

The quantitative model of the lead time distribution at ProActive is described as a random forest, consisting of 600 trees. Each decision tree takes a random combination of three of the seven possible independent variables into account. The predictions of each of these 600 different trees are then combined to calculate a prediciton with a low error. Plotting all 600 trees would obviously not provide a legible overview. Therefore, two of the 600 trees are plotted to give an idea of how the trees in the forest look like (Figure 27).

Figure 27: Two of the trees contained with the random forest.



Even though it is difficult to visualize the whole forest, it is still a valid quantitative model for making predictions on lead times of ProActive's future projects. Using the random forest implementation in R, a predicted lead time can be computed by providing values for

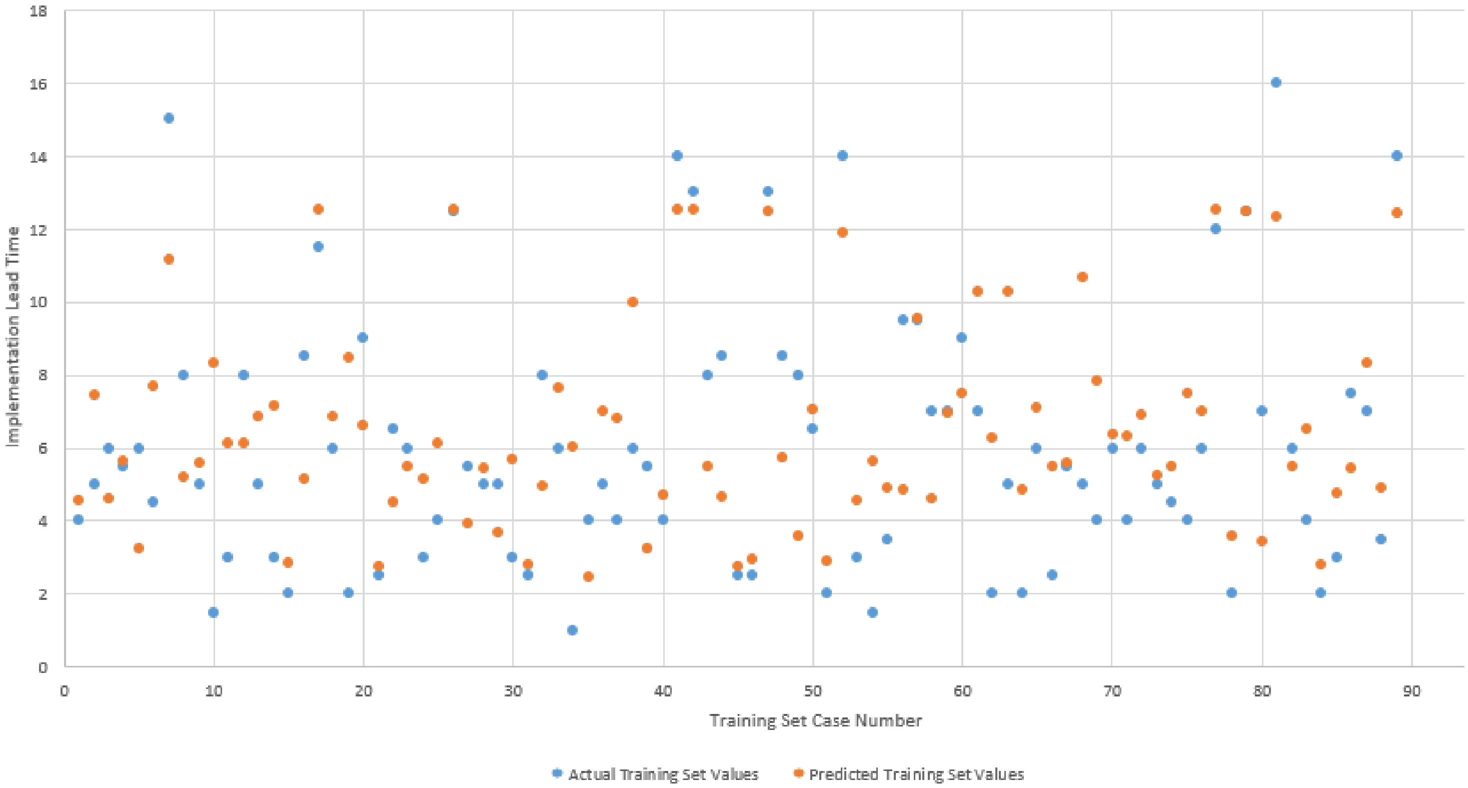
[67] A search that tests all possible combinations of parameters to see what combination would lead to the best possible performance.

the seven independent variables[68] (SQ 6a). The remainder of this sub-section will assess how accurate these predictions are, if the model is an improvement compared to how ProActive currently predicts their lead times, and what the relative importance of the different factors is based on the quantitative model.

5.3.2.2.2 Training Model Goodness of Fit

To assess the goodness of fit between the *training model* predictions and the actual values of the *training model*, the R squared method[69] was applied. With this method, the explained variation is divided by the total variation which returns a percentage, where a higher percentage[70] shows a better fit of the regression model on the training set data compared to a lower percentage (Minitab, 2013). Applying the R-squared method on the training set returned a percentage of 65.09%, which means this model accounts for 65.09% of the variation in the test set.

Figure 28: Complete Sample Set: Predicted Training Set Values vs. Actual Training Set Values



To test the R Squared percentage on significance, an F-test was performed. The F-test checks whether the quantitative model that takes the different factors into account performs significantly better than the current model, that does not take the different factors into account (Statisticshowto, 2021). Hereby, H0 claims there is no significant difference between the two models. The f-statistic is calculated by $F = s^2_1 / s^2_2$, where s^2_1 is the squared variance of the first sample group, and s^2_2 is the squared variance of the second

[68] For example, for a project with a company from the education industry, where no new connection is required, where the consultant is not in his first half year at ProActive, where the third implementation type is being implemented, where a below average amount of support is required, where the deadline of the project is not around new year's eve, and where multiple modules are implemented at the same time, the model predicts a lead time of 5.47 months.

[69] A statistical measure that shows how close the prediction is to the actual training set data (Minitab, 2013).

[70] The closer the R-squared is to 100%, the better the fit of the model.

sample group ([Statisticshowto, 2021]). This returned a F-statistic of 2.36. This corresponds to a p-value of 0.00001, which means H0 can be rejected. This means the increase in predictive performance based on the predicted values for the training set and the actual values of the training set is significant at $p < 0.05$.

5.3.2.2.3 Performance Evaluation

To evaluate the performance of the predictive model, the difference between the predicted values and the actual values of the *test set* were assessed. With the optimal combination of three random predictors and 600 trees, the MSE became stable at 7.09 (Figure 29). The goodness of fit of the predictions for the test set and the actual values of the test set is depicted in figure 30.

Figure 29: Complete Sample Set Random Forest MSE

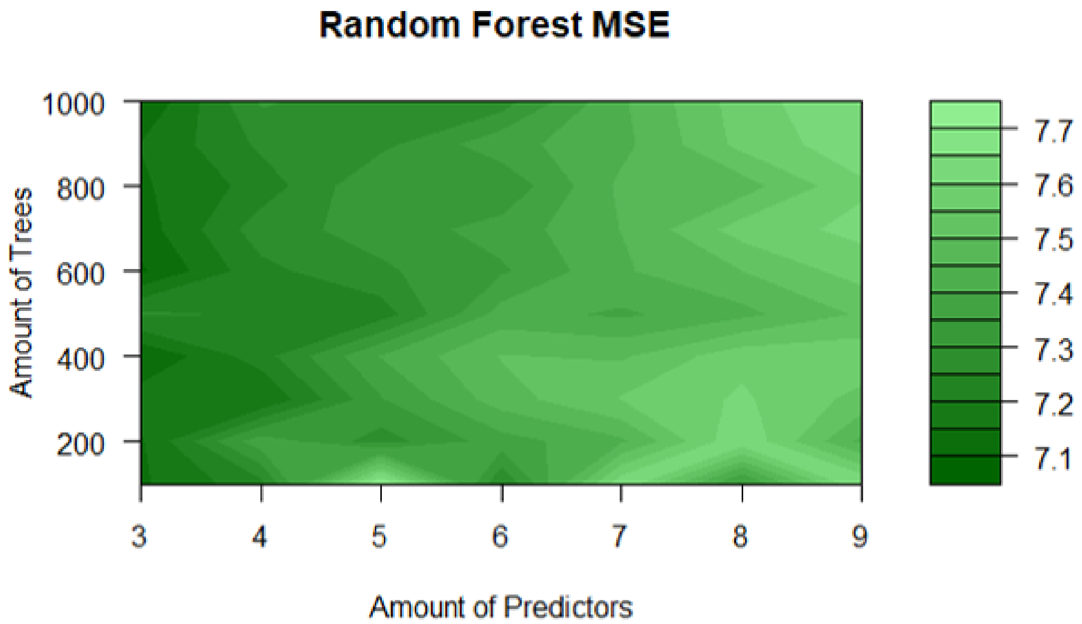
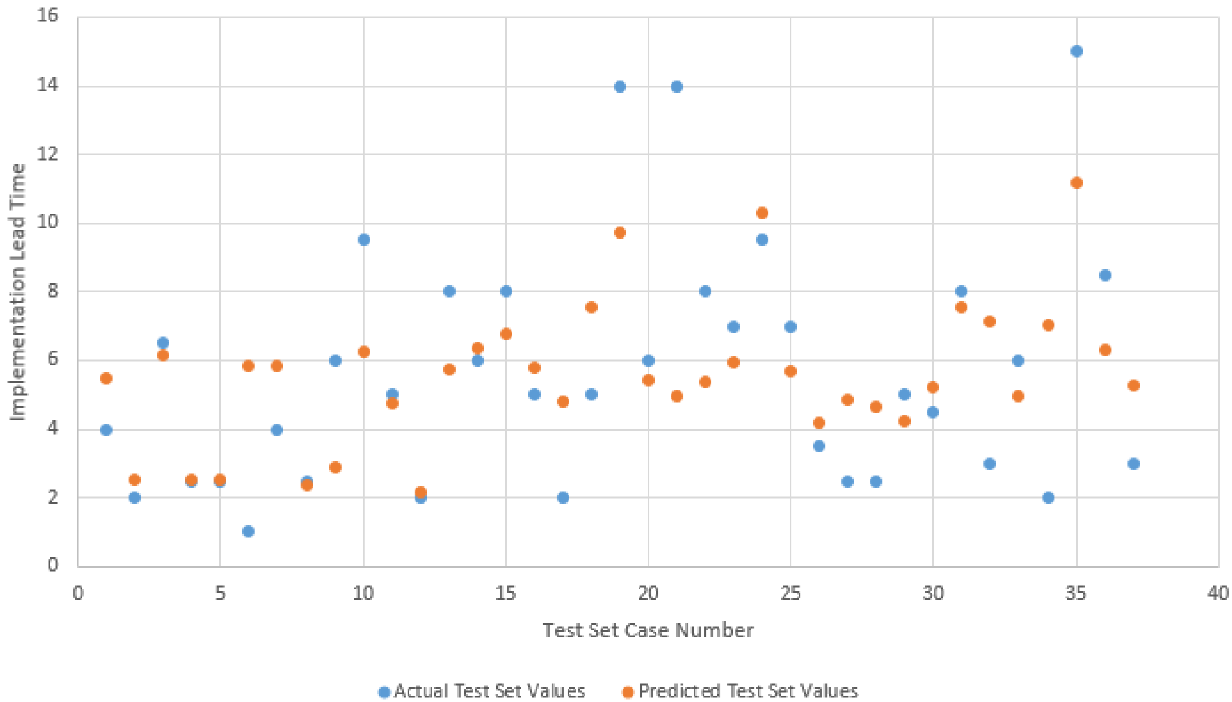


Figure 30: Complete Sample Set: Predicted Test Set Values vs. Actual Test Set Values



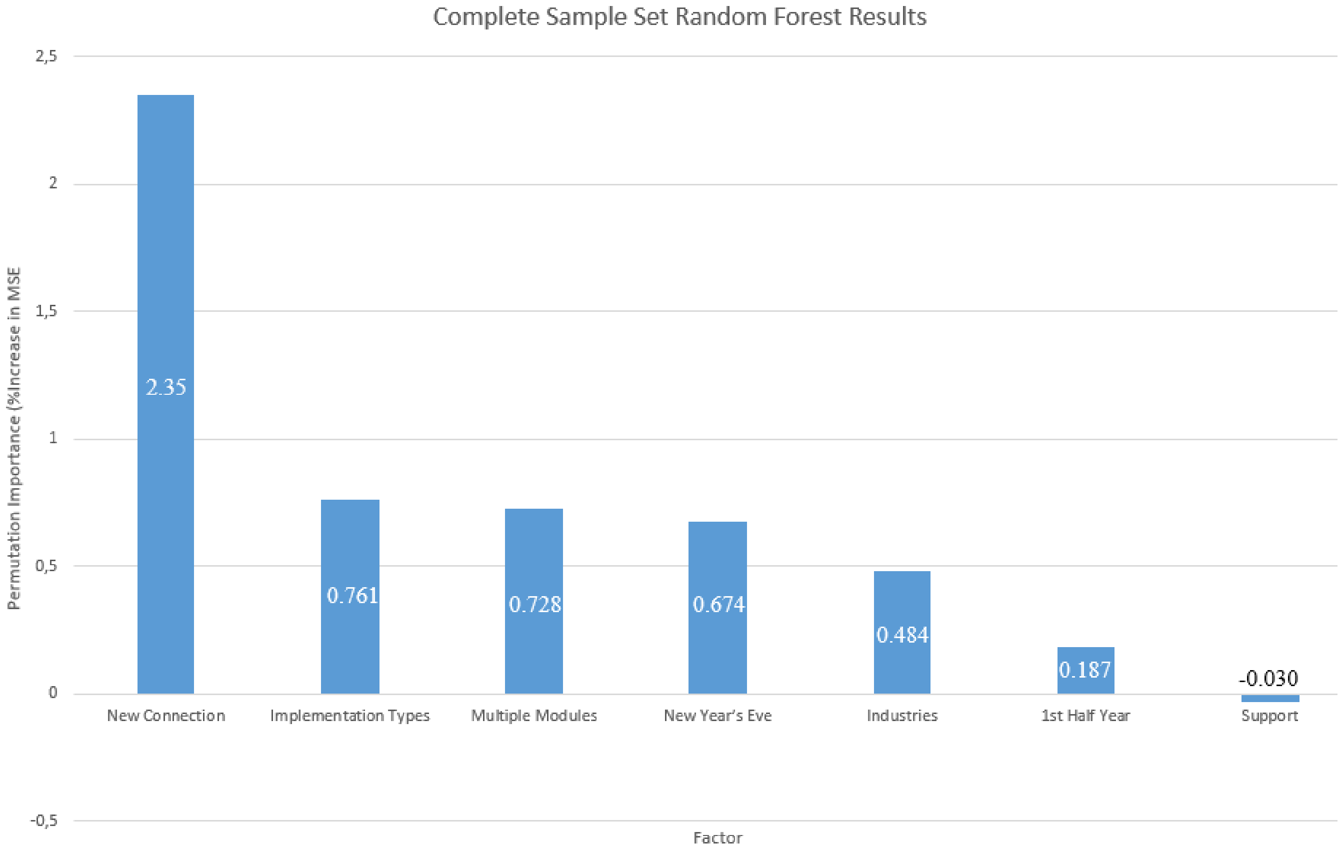
Taking the square root of the MSE results in the *'Root Mean Squared Error'*, which shows the average distance between the predictions for the test set and the actual values of the test set (James et al, 2013). In other words, the RMSE shows how far away from the actual values the prediction of the regression model is.
The square root of 7.09 is equal to 2.66. This means the prediction model on average predicts the lead time of a project around 2.66 months away from the actual lead time of a project.
At the moment, ProActive predicts the implementation lead time of every project will be around six months, because their average lead time is also around six months. However, the standard deviation of the complete sample set is 3.24 months. This means the predictions ProActive makes at the moment have a RMSE of 3.24 months. On the other hand, if ProActive would predict the lead times of all of their projects based on the quantitative model, their RMSE would decrease to 2.66 months. This is a reduction of 17.90%.
To test this reduction on significance, again an F-test was performed. This returned a p-value of 0.00001, which provides significant evidence that the predictive model is a significant improvement compared to the current model. This shows the quantitative model from the complete sample set provides the opportunity for ProActive to make better predictions.

5.3.2.2.4 Factor Importance

Now that we know the predictive model performs better than the current model, the relative importance of the different factors will be quantified. The random forest algorithm assigns a specific '*permutation importance'* to each factor, which represents the relative importance of each feature. This 'permutation importance' of a specific factor is a percentage that shows how the MSE of the prediction would change if that specific factor would be excluded from the forest. This also works the other way around: the permutation importance percentage also shows how the mean squared error decreases when a specific factor is added to the forest. The variable with the largest decrease in accuracy or largest increase in error rate is thus considered the most important variable, because not considering that variable has the largest penalty on the prediction (Rbloggers, 2019).

Figure 31 shows the permutation importance of each factor from the complete sample set.

Figure 31: Complete Sample Set Random Forest Results

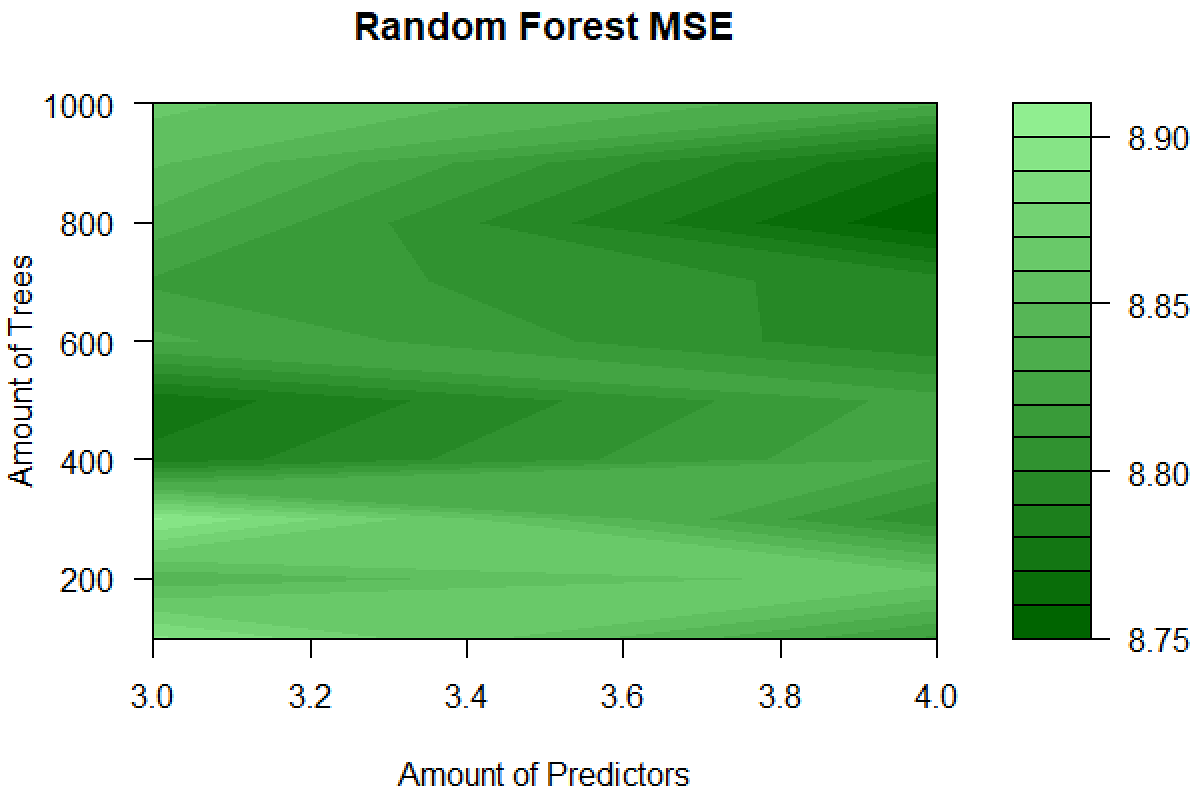


The factors '*multiple modules*', '*new year's eve*', and '*industries*' were not found in the theoretical framework. As mentioned in sub-section 5.1.3, these factors came forward out of the analysis of the case study data. The above mentioned importance of these three different factors shows that the MSE of the forest is substantially higher when these factors would be excluded from the forest.

To further assess the importance of the company specific factors[71], the performance of the model based on the complete sample set with these factors excluded from the dataset was tested. This time, the *adjusted R-squared*[72] was used to calculate the training set goodness of fit without the company specific factors. The adjusted R-squared is calculated as follows: 1 – (1 – R^2) ((N-1) / (N – k – 1)), where N is the sample size, k is the amount of independent variables in the model, and R^2 is the R-squared. As the formula shows, when k increases, the adjusted R^2 value decreases. In this way, the adjusted R-squared also takes a difference in the amount of independent variables into account (Miles, 2005).
Calculating the adjusted R-squared percentage of the set with the company specific factors included resulted in a percentage of 62.08%. The adjusted R-squared of the set without the company specific factors is 49.95%. This is a difference of 12.13%.
Next to this, the MSE was also again calculated. Without the company specific factors, the tuning algorithm returned the combination of 4 random predictors and 800 trees as the optimal combination. Hereby, the MSE stabilized at 8.75 (figure 32).

[71] The factors '*Deadline New Year's Eve'*, *'Multiple Modules'*, and '*Customer Industries'* were found in the company specific elements analysis.
[72]

Figure 32: Complete Sample Set Random Forest MSE without company specific factors.



This MSE is 1.66 higher than the MSE of the model that includes the company specific factors. This shows the random forest performs worse when the company specific factors are not included in the dataset. This shows an optimally accurate prediction model cannot be created for ProActive when only factors from literature are taken into account, since the prediction accuracy substantially decreases when case specific factors are excluded from the forest.

5.3.2.3 Interview & Survey Sub-Sample Set Random Forest

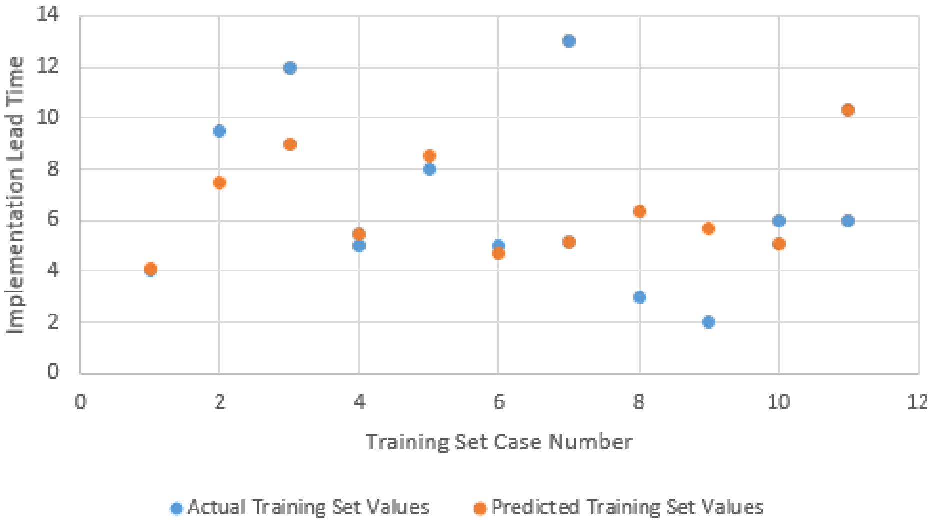
When applying regression with three independent variables, a general rule of thumb is to have a sample size of at least 30 cases (Statisticssolutions, 2020). Having more than three independent variables requires an even bigger sample size than 30 cases, for the regression test to return reliable results (Statisticssolutions, 2020). For this reason, we decided to only develop the quantiative model of lead time distribution with the complete sample set, since the sub-sample set has less than 30 cases and more than three independent variables. Therefore, for the sub-sample set, only the permutation importance of the different factors will be calculated with the random forest.

For the interview & survey sub-sample set, we applied the exact same approach as was used for the complete sample set. With the new data from this sub-sample set, a new random forest was created in the same way as was done for the complete sample set. For the sub-sample set, the tuning algorithm showed the combination of four random predictors and 500 trees leads to the lowest possible MSE.

5.3.2.3.1 Training Model Goodness of Fit

To assess the predictive performance on the training set from the sub-sample set, again the R-squared method was used. Applying the R-squared method on the training set returned a percentage of 31.72%, which means this model accounts for 31.72% of the variation in the test set.

Figure 33: Sub-Sample Set: Predicted Training Set Values vs. Actual Training Set Values



Again, the F-test was performed to test this 31.72% on significance. This F-test returned a p-value of 0.12, which means the added parameters do not significantly increase the model's predictive performance. This indicates a low goodness of fit based on the predicted values for the training set and the actual values of the training set. This confirms we cannot develop an accurate predictive model based on the interview & survey sub-sample set.

5.3.2.3.2 Performance Evaluation

With the optimal combination of four random predictors and 500 trees, the MSE became stable at 10.77 (figure 34). The goodness of fit of the predictions for the test set and the actual values of the test set is depicted in figure 35.

Figure 34: Sub-Sample Set Random Forest MSE

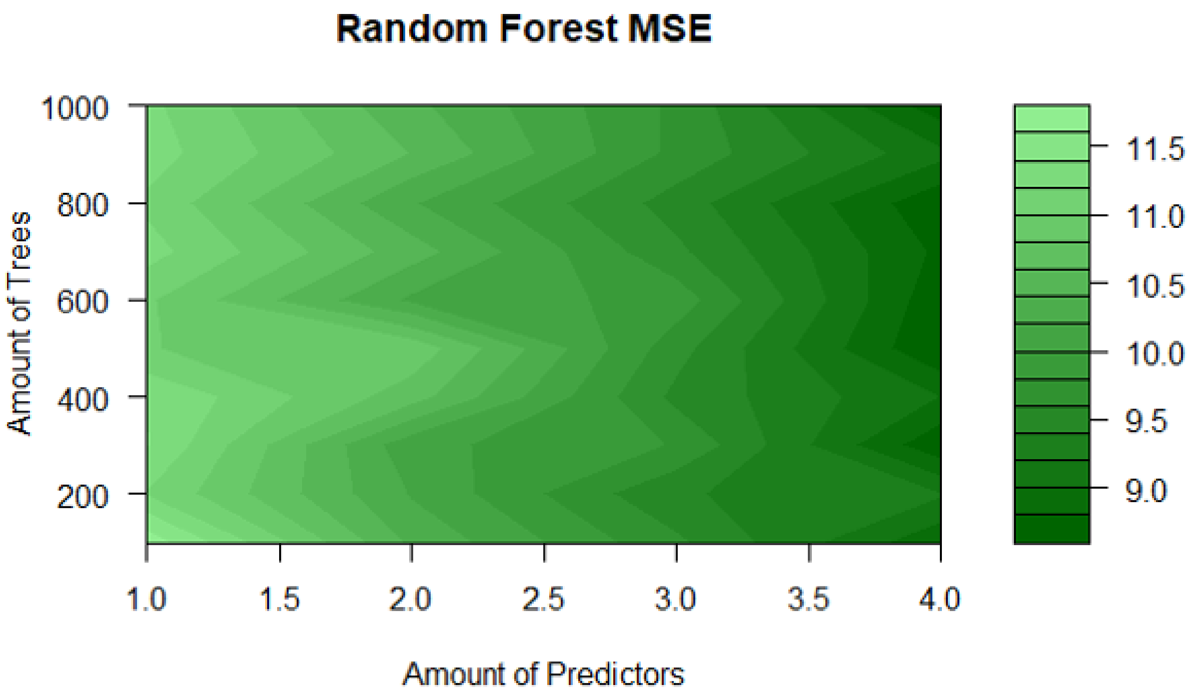
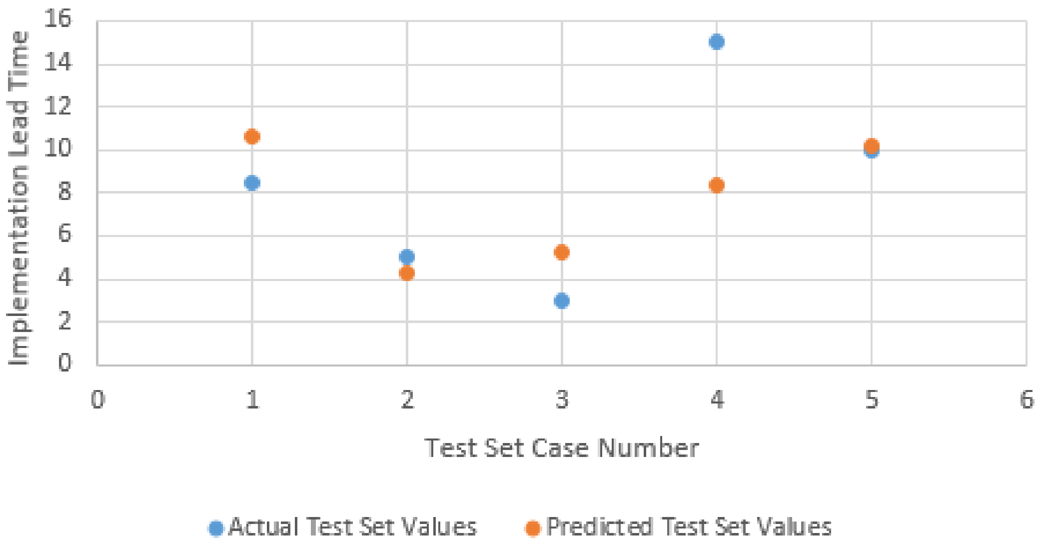


Figure 35: Sub-Sample Set: Predicted Test Set Values vs. Actual Test Set Values



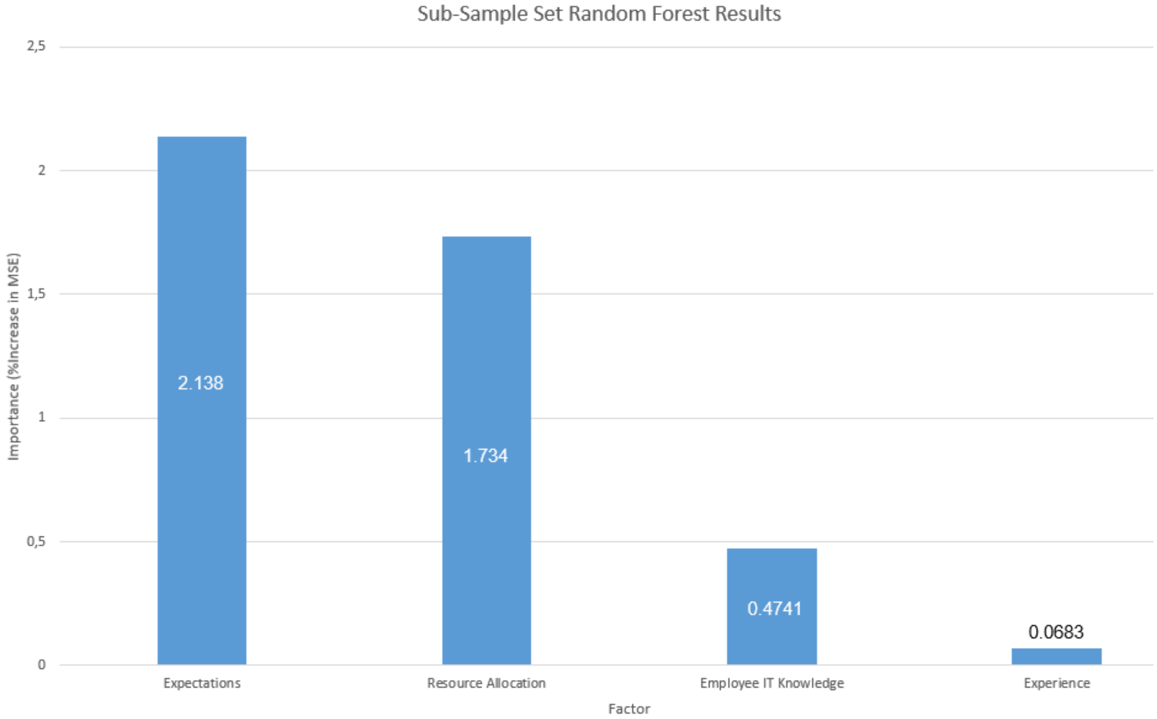
The RMSE between the predictions and the actual values of the test set is 3.28 months[73]. This is 0.62 months higher than the RMSE of the predictions from the complete sample set. Also, an F-test was again performed, to test if the predictive model based on the sub-sample set is a significant improvement compared to when no parameters would be used for making the predictions. This returned a p-value of 0.165, which means the predictive model on the basis of the sub-sample set is not a significant improvement compared to when ProActive would predict their lead times on the basis of the average lead time of the sub-sample set. This was also expected, as this sub-sample set has a significantly lower amount of cases than the complete sample set.

5.3.2.3.2 Factor Importance

Even though the model on the basis of the sub-sample set does not significantly perform better than the current model, the relative importance of the different factors was still quantified with the random forest. Figure 36 shows the permutation importance of each factor from the sub-sample set.

[73] The square root of 10.77 is equal to 3.28.

Figure 36: Interview & Survey Sub-Sample Set Random Forest Results



Even though the results from this forest are less reliable than the results from the forest of the complete sample set, the relative importance that is shown in figure 36 was expected. The reason for this is the factors '*Customer Expectations'* and *'Resource Allocation'* were also the only two factors that came forward as significant from the Two-Sample T-Tests, whereas the factors '*Employee IT-Knowledge'* and '*Customer Experience with Similar Implementations'* did not come forward as significant. Additionally, the factors '*Customer Expectations'* and '*Resource Allocation'* also came forward out of the interviews as two of the most important factors that influence the implementation lead time. This confirms that out of the sub-sample set, the factors '*Customer Expectations*' and '*Resource Allocation'* have the highest impact on the implementation lead time.

5.4 Conclusion

In this chapter, the list factors from the literature model were tested on relevance in a specific business setting. Also, this list of factors was complemented with company specific factors. This complemented list of factors was then used to develop a quantitative model of the lead time distribution, based on local company data related to these factors.

Testing the impact of the factors from the literature model in the context of ProActive showed there are several differences between literature and the case study. For example, the factors '*Customer Adaptability'*, '*Customer Experience'*, *'Customer Skills'*, *'Consultant's Level of Assistance'*, and *'Training / Education'* came forward in literature as factors with a significant impact on SPI lead time, whereas they did not come forward as significant influencing factors of ProActive's lead time. Also, the described relative importance of the factors from the literature model is different to the relative importance of the factors in the context of the case study[74].This shows what the most important factors

[74] In literature, the factors 'top management support' and 'project management' were the most important factors, whereas in the case study the factors customization and customer expectations came forward as the most important.

are for a software package supplier can depend on the context[75]. Therefore, in order to accurately predict their SPI lead times, it is important for software package suppliers to quantify what the most important factors that influence SPI lead time are in their company specific context. This can for example be done by using the in this research demonstrated method.

Next to this, testing the company specific factors on significance showed the theoretical framework does not cover all important factors that influence SPI lead time for every specific business setting. For example, the factors '*Customer Industry*', '*Multiple Modules'*, and '*Deadline New Year's Eve'* did not come forward as important out of the theoretical framework. However, these factors did come forward as important factors from the random forest and the hypothesis tests.
Evaluating the predictive model performance without including the company specific factors in the model showed the predictive performance of the model significantly decreases when these factors are not taken into account. This shows it is not possible for ProActive to create an accurate predictive model based on literature, because company specific factors also have to be taken into account.
This also shows not taking important factors that influence the lead time into account leads to a lower regression performance, compared to when all important factors would be taken into account. This means the quantitative model from sub-section 5.3.2.2.1 still has room for improvement: important factors like '*customer expectations'* and ´*resource allocation'* were not incorporated in the model. Moreover, factors like '*project management'* and '*customer preparation'* could not be incorporated in the model because of multicollinearity. A more accurate quantitative model than the model in section 5.3.2.2.1 thus can only be created when ProActive has more accurate data available about more of the important factors that influence the implementation lead time[76].

The ranking of the most important factors that influence ProActive's lead time is shown in table 12, based on the permutation importance of the different factors that was calculated in the previous section. Hereby, it is also mentioned if a specific factor tested as significant in the hypothesis tests. Table 12 shows the answer to SQ 4.

Table 12: Relative Importance of the different factors that influence ProActive's lead time

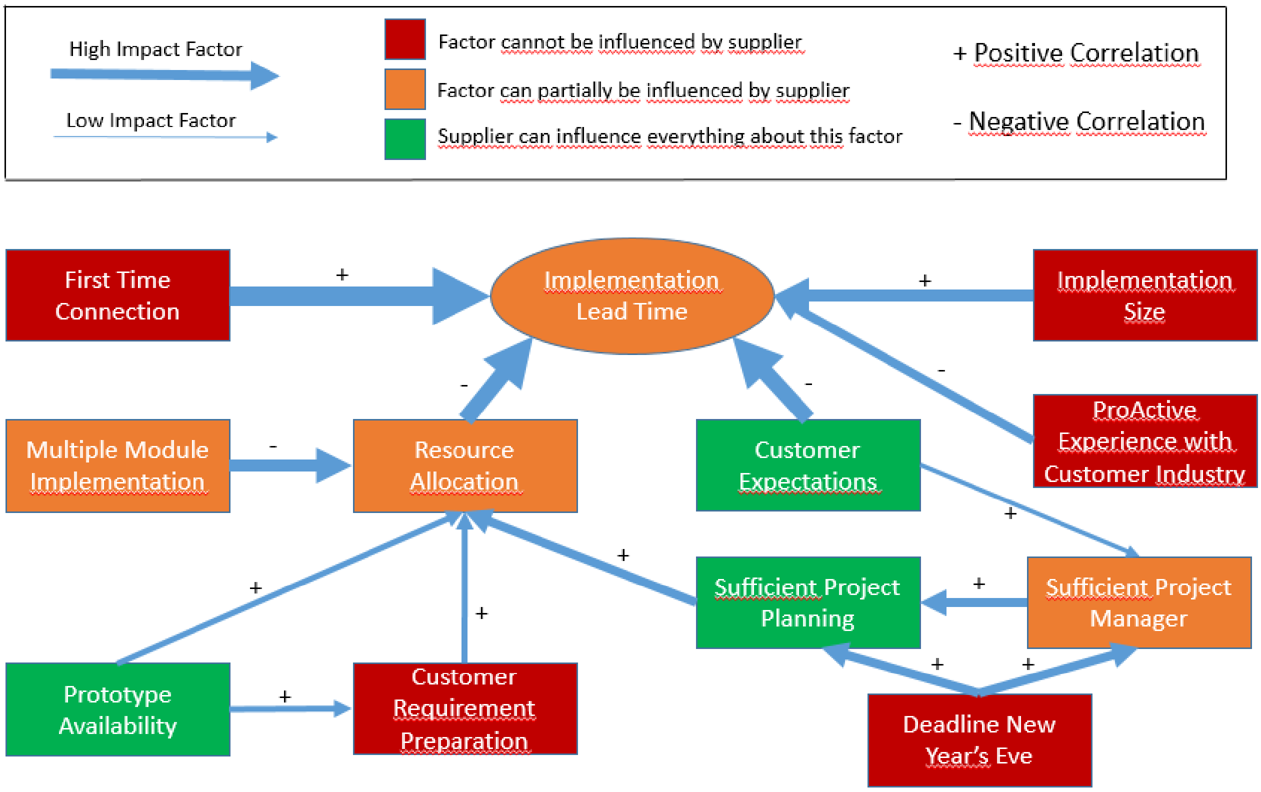
Factor Importance Ranking	**Factor Name**	**Tested as Significant?**
1	New Connection (Customization)	Yes
2	Customer Expectations (About the product's functionality and division of roles in the project)	Yes
3	Resource Allocation	Yes
4	Implementation Types (Implementation Size)	Yes
5	Multiple Module Implementations	Yes

[75] For example, the factor 'customization' turned out to be more important in the context of ProActive compared to in the ASP process. The reason for this is in ProActive's process a connection with the customer's financial system has to be made, whereas the ASP process does not contain this 'connection-step'.
[76] For example: in their current project administration, ProActive does not maintain information about whether a customer had a prototype available during a project, or not. If ProActive would register in their project administration for every project if a customer had a prototype available or not, this would make it possible to increase the predictive performance of the quantitative model.

6	Deadline around New Year's Eve	Yes
7	Customer Industries	Yes
8	Customer Skills	No
9	Consultant First Half Year (Consultant's Level of Assistance)	No
10	Customer Experience with Similar Implementations	No
11	Support calls (Customer Adaptability)	No

Figure 37 provides a visualized overview of this relative importance, the correlations between the independent variables and if ProActive can influence these factors completely, partially, or not at all. In this way, even though the quantitative model could not be visualized, we still have an overview of the relative impact of every different factor on both the lead time and the other factors.
The correlations between the different variables are mainly based on the spearman correlation coefficients. The degree of influence of a specific factor is based on the quantitative model from the previous section. The supplier's influence is based on how these factors play a role in the context of ProActive, and how the supplier's influence was described in the literature model.

Figure 37: Importance and Inter-Correlations of the factors that influence the implementation lead time.



Based on what factors ProActive can influence, in order to minimize their average lead time, it is important for them to make sure that in every single project (SQ 6b):

- The customer's expectations are completely in line with what ProActive has in mind.
- The customer's resources and competencies are sufficiently allocated.

- Multiple modules are only being implemented at the same time when this does not negatively impact the 'resource allocation' factor.
- A prototype is available for the customer.
- The planning is tight and sufficiently monitored.

This also means, from the top five of ProActive's most important factors (table 12), only the factors '*new connection (customization)'* and '*implementation types'* cannot be influenced by ProActive. Even though the factor '*new connection (customization)'* has the most significant impact on ProActive's lead time, sometimes customization will still be required in a project. Not every potential customer with a new financial system should thus be accepted, because a project with such a customer significantly increases the average lead time. However, as mentioned before, when such new financial system is also in use at several other potential customers, making such a new connection could be profitable for ProActive on the long term. Therefore, as Piller (2004) also states, before such a project is started, ProActive should analyse whether more potential customers are using the same financial system and if the longer lead time on the first project with this financial system will be worth it on the long term.

6 Conclusions and Outlook

6.1 Conclusion

The main purpose of this study was to demonstrate a method that can be used by software package suppliers to determine the most important factors that influence their lead times, and to accurately predict their implementation lead times. This subject is important, because for software package suppliers, implementation lead time is one of the main elements of implementation success. Knowing what influences their average implementation lead time enables these suppliers to know where to take action to improve their implementation process, in able to make their average implementation lead time decrease. Also, having a quantitative model of the lead time distribution makes it possible to predict implementation lead times for future projects.

In this research, first a literature search was performed to find an answer to SQ 1. To answer SQ 1a, a process model of the ASP implementation process was derived from literature. Hereby, it was noticed that in a very little amount of papers a SPI process was actually modelled.
For SQ 1b, the most important factors that influence the lead time of a SPI process were derived from literature and incorporated in a literature model. Hereby, it was noticed the impact of the factors was only described related to the whole process, instead of on an activity level.

After the theoretical framework, we wanted to test the models from literature in the context of a case study. Therefore, the process model that was derived from literature was compared to the process model of P2P software supplier ProActive (SQ 2). This 'modelling analysis' brought to light how the P2P implementation process coincides with the more general ASP implementation process, and how the two processes are different to each other. This showed it is important to assess the differences between the two processes, to be able to explain why a specific factor has a different impact in a different implementation process. For example, the quantitative model showed customization is a more important factor in ProActive's process than in the ASP process. This could be explained, because the ASP process did not contain a 'customization' step, whereas ProActive's process did have a separate 'customization' step.

Analysing ProActive's process also opened up the opportunity to assess how the lead time was divided over the process (SQ 3). ProActive's project administration contained information about the lead times of the different phases in the project. This project administration showed the pilot-phase is the main bottleneck in ProActive's implementation process.

Furthermore, analysing ProActive's process showed a lot of similarities exist between the ASP implementation process and ProActive's process: every step of the ASP process was also present in ProActive's process, except for the *'internal procedure modification'* step. This showed the investigated literature had a context comparable to the context of our case study. Therefore, we assumed it would be useful to test the literature model in the company specific context of our case study (SQ 4).

However, before the literature model could be tested in the context of ProActive, the available data had to be prepared. Hereby, we first operationalized the factors from literature that could be operationalized with the original project administration. Hereafter, the problem of missing data was addressed: insufficient cases were removed from the dataset, and information about the factors that were not operationalized was added to the dataset through interviews and surveys.

Then, an exploratory analysis of data was performed to add potential company specific factors to the dataset. The factors that emerged from this exploratory analysis were added to the list of factors from the literature model. The relative importance of all these factors was later quantified by applying random forest, which answered SQ 4. This relative factor importance is shown in table 12.

The random forest was also used for the development of a quantitative model of the lead time distribution at ProActive (SQ 5). This quantitative model showed to improve the predictive capabilities of ProActive by 17.90%. An F-test showed this to be a significant improvement.
Hereby, it was also assessed how the model would perform without the company specific factors that emerged from the exploratory analysis of data. This showed the model's adjusted R-squared percentage decreases with 12.13% when the company specific factors are not included in the model, which is a significantly worse performance compared to the performance of the model that does include the company specific factors. This underlined the importance of analysing the impact of the different factors in the context of a specific business setting. Moreover, this also showed adding important factors that influence the lead time to the list of independent variables that the predictive model uses can significantly increase the performance of the model.

All in all, this research showed using the approach that is described above in a company specific context on the one hand helps the specific company to better predict their lead times (SQ 6a), and on the other hand helps them to decrease their average lead times (SQ 6b). Even though ProActive's project administration was not originally designed with the purpose of developing a predictive model, using the predictive model based on their project administration did show to significantly increase their predictive capabilities with 17.90%. Moreover, because of the missing data in the project administration, it is possible for ProActive to increase their predictive capabilities even more in the future by adding this missing data to their project administration. For example, the project administration did not contain information about if a customer had a prototype available before starting the implementation project or not, or if the required resources were sufficiently allocated or not. If ProActive would maintain information about all these 'missing data factors[77]' in their project administration in the future, it would thus be possible for them to improve their predictive capabilities even further.

Investigating the relative impact of the different factors on ProActive's lead time led to the conclusion that the factors 'customization', 'customer expectations', and 'resource allocation' are the most significant influencing factors of their implementation lead time. Also, it was also found that several inter-correlations exist between the different factors:

[77] The factors from the interview & survey sub-sample set, and the factors that could not be tested due to the response bias.

the factors ‘customer preparation’, ‘prototype available’, and ‘customer adaptability’ are not directly correlated with the implementation lead time, but do have an indirect impact because they are correlated with other factors that do have a direct impact on the implementation lead time. These findings are all summarized in Figure 37.
The relative importance of the factors in ProActive’s process was different than the relative importance of the factors described in the literature model. This shows what the most important factors are for a software package supplier can depend on the company specific context. Therefore, it is important for software package suppliers to quantify what the most important factors that influence SPI lead time are in their company specific context. This can be done by using the in this research demonstrated approach.

Acting upon the finding that the factors ‘customization’, ‘customer expectations’, and ‘resource allocation’ are the most important for ProActive should enable them to lower their average implementation lead time (SQ 6b). For example, because this study quantified the impact of the factor ‘customization’ on their implementation lead time, it is now possible and highly recommended to accurately analyse if a project where customization is required will be profitable in the long-term or not. Also, in the interviews, often the respondent stated the expectations about the system’s functionality were in line with what the system could offer, but the expectations about the division of roles in the project and how to fill in those roles in an efficient way were often different to what ProActive had in mind. Therefore, to decrease their lead times, it is also useful for ProActive to focus more on accurately explaining to the customer what ProActive will do, but also what they will not do, and what resources the customer will need to efficiently execute their role in the project.

6.2 Outlook

The findings from this research provide several opportunities for future research. Most importantly, the demonstrated research approach has to be repeated in the context of different software package suppliers to be able to see how this approach works in a different context. Also, in able for ProActive to make predictions and improve their whole P2P process, this research would have to be repeated for the other possible modules that are part of their P2P implementation process[78].

Next to this, it is advised for ProActive to set up a procedure to start using the predictive model. Hereby, it is also advised for ProActive to add information about the ‘missing data factors’[79] to their project administration for future projects. As mentioned before, this would improve their predictive capabilities.

Furthermore, the recommendations for ProActive from section 6.1 have to be implemented to see if the recommended actions actually decrease their average implementation lead time, because it is not scientifically proven that these recommendations decrease the lead time in ProActive’s company specific context.

[78] In this case, the procurement- and contract-management modules.
[79] As mentioned before, the factors from the interview & survey sub-sample set, and the factors that could not be tested due to the response bias.

Moreover, if ProActive would start registering the lead times of the different activities of their SPI process, it will be possible to compare the activities of ProActive to the activities in the process of other SPI software suppliers. This would make it possible to analyse what steps in the process could be a bottleneck, or are crucial in achieving a lower average implementation lead time.

This research also opens up the opportunity to study how the factors that influence the implementation lead time from this study influence other important elements of implementation success. When acting upon these factors, it is important to not harm the overall customer experience, which makes it interesting to research the impact of the findings from this study on other important elements.

All in all, this research raises several interesting topics for future research: How do these factors impact other important elements of implementation success? How are these factors most efficiently addressed? How are these factors applicable in the context of other organizations? How are these factors applicable in the implementation of other P2P software products? It is clear that this research provides interesting opportunities for future work.

Bibliography

al, J. e. (2009). *Software Development Effort Estimation: Formal Models or Expert Judgment?* Retrieved from https://www.researchgate.net/publication/224387112_Software_Development_Effort_Estimation_Formal_Models_or_Expert_Judgment

Alin, A. (2010). *Multicolinearity*. Retrieved from Onlinelibrary.wiley.com: https://onlinelibrary.wiley.com/doi/abs/10.1002/wics.84

Breiman. (2001). *Random Forest Models*. Retrieved from http://journals.plos.org/ploscompbiol/article/file?type=supplementary&id=info:doi/10.1371/journal.pcbi.1004583.s015#:~:text=The%20random%20forests%20(RF)%20approach,(Breiman%20L%2C%202001).&text=We%20used%20the%20mean%20squared,accuracy%20of%20the%20RF%20

Brownlee, J. (2020). *What is the difference between test and validation datasets?* Retrieved from machinelearningmastery.com: https://machinelearningmastery.com/difference-test-validation-datasets/

Bryant, J. (2016). *The beginning is the most important part of work*.

Chaturvedi et al. (2011). *Software Package Implementation Sizing*. Retrieved from Patentimages.storage.googleapis.com: https://patentimages.storage.googleapis.com/9a/99/c1/3c87ae16b7dba3/US8020147.pdf

Cohen, B. (2011). *New rules for the decade of financial visibility*. Retrieved from Global-factiva-com.ezproxy.leidenuniv.nl: https://global-factiva-com.ezproxy.leidenuniv.nl:2443/ga/default.aspx

Cohen, J. (1988). *Statistical Power Analysis*. Retrieved from http://www.utstat.toronto.edu/~brunner/oldclass/378f16/readings/CohenPower.pdf

Cubedo et al. (2002). *Hypothesis testing: A model selection approach*. Retrieved from ResearchGate: https://www.researchgate.net/publication/228635471_Hypothesis_testing_A_model_selection_approach

Dachyar et al. (2016). *Improvement of procurement business process (procure-to-pay) in Indonesian shipping company*. Retrieved from https://books.google.nl/books?hl=en&lr=&id=n7f1CwAAQBAJ&oi=fnd&pg=PA215&dq=procure+to+pay+&ots=YWbMX0wCF 7&sig=BcX-YSoTTd-k_WrJGeUVTV4Cmrc&redir_esc=y#v=onepage&q=procure%20to %20pay&f=false

Donges, N. (2019). *A complete guide to the random forest algorithm*. Retrieved from https://builtin.com/data-science/random-forest-algorithm

Eisenhardt et al. (1989). *Building theories from case study research*. Retrieved from https://www.jstor.org/stable/258557?seq=1#metadata_info_tab_contents

Epizotone et al. (2019). *Critical success factors for ERP system implementation to support financial functions*. Retrieved from https://www.abacademies.org/articles/critical-success-factors-for-erp-system-implementation-to-support-financial-functions-8837.html

Erazo et al. (2017). *Analysis of software implementation process for ERP systems*. Retrieved from https://www.researchgate.net/publication/319139732_Analysis_of_the_Software_Implementation_Process_for_ERP_Systems

Fairley, R. (2009). *Managing and leading software projects*. Retrieved from https://books.google.nl/books?id=PiY9dknFfaIC&pg=PT449&lpg=PT449&dq=problem+of+lead+time+software+projects&source=bl&ots=BGdVtxG6R&sig=ACfU3U0wpuO8fuRqhZAWaBMzdw7sMeZ7SA&hl=en&sa=X&ved=2ahUKEwjrtJH1nrjqAhXE0aQKHbADAjoQ6AEwC3oECAkQAQ#v=onepage&q&f=false

Fang et al. (2005). *Critical success factors in ERP implementation*. Retrieved from http://www.diva-portal.org/smash/get/diva2:3922/fulltext01.pdf

Frederiks et al. (2005). *Information modeling: the process and the required competencies of its participants*. Retrieved from https://www.sciencedirect.com/science/article/pii/S0169023X05000753

Furnham, A. (1986). *Response bias, social desirability and dissimulation*. Retrieved from https://www.sciencedirect.com/science/article/pii/0191886986900140

Gerhardter et al. (2013). *Flexibility and improved resource utilization through cloud based ERP-systems: Critical success factors of SaaSsolutions in SME.* Retrieved from https://link.springer.com/chapter/10.1007/978-3-642-37021-2_14

Gevers et al. (2009). *Team self-regulation and meeting deadlines in project teams: Antecedents and effects of temporal consensus*. Retrieved from https://www.tandfonline.com/doi/abs/10.1080/13594320701693217

Goldsmith, R. (1985). *Pick Package like a Mate*.

Holland et al. (1999). *A Critical Success Factors model for ERP implementation*. Retrieved from https://ieeexplore.ieee.org/abstract/document/765784

Hong, K.-K. (2002). *The critical success factors for ERP implementation: an organizational fit perspective*. Retrieved from https://www-sciencedirect-com.ezproxy.leidenuniv.nl:2443/science/article/pii/S0378720601001343

Iivari, J. (1990). *A paradigmatic analysis of information systems as a design science*. Retrieved from https://www.researchgate.net/publication/201168950_A_paradigmatic_analysis_of_information_sys

James et al. (2013). *An Introduction to statistical learning with applications in R*. Retrieved from file:///C:/Users/Rutger/Downloads/An%20Introduction%20to%20Statistical%20Learning%20-%20James%20Witten%20Hastie%20Tibshirani.pdf
Jorgensen et al. (2008). *Software Development Effort Estimation: Formal Models or Expert Judgment?* Retrieved from https://www.researchgate.net/publication/224387112_Software_Development_Effort_Estimation_Formal_Models_or_Expert_Judgment
Joshi, P. (2017). *When to Use Linear Regression, Clustering, or Decision Trees*. Retrieved from dzone.com: https://dzone.com/articles/decision-trees-vs-clustering-algorithms-vs-linear
Kagdi et al. (2009). *Who can help me with this change request?* Retrieved from https://sci-hub.se/https://ieeexplore.ieee.org/abstract/document/5090056
Kenton, W. (2020). *Lead Time*. Retrieved from Investopedia: https://www.investopedia.com/terms/l/leadtime.asp#:~:text=Lead%20time%20is%20the%20amount,%2C%20and%20post%2Dprocessing%20stages.
Keselman et al. (2004). *The New and Improved Two-Sample t Test*. Retrieved from https://journals.sagepub.com/doi/abs/10.1111/j.0963-7214.2004.01501008.x
Kim, T. K. (2017). *Understanding one-way ANOVA using conceptual figures*. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5296382/
Kofax. (2020). *10 ways manual tasks are costing your business*. Retrieved from https://www.kofax.com/-/media/Files/E-books/EN/eb_ten-ways-manual-tasks-are-costing-your-business_en.pdf
Lebel et al. (2018). *A unified framework to quantify the credibility of scientific findings*. Retrieved from https://scihub.wikicn.top/10.1177/2515245918787489
Leenders et al. (1994). *Adapting Purchasing to Supply Chain Management*. Retrieved from https://www.researchgate.net/publication/235261588_Adapting_Purchasing_to_Supply_Chain_Man
Light, B. (2005). *Potential pitfalls in packaged software adoption*. Retrieved from https://www.researchgate.net/publication/220422715_Potential_pitfalls_in_packaged_software_ado ption
Liu et al. (2017). *The Effect of Extreme Response and Non-extreme Response Styles on Testing Measurement Invariance*. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5440768/
Lucas et al. (1988). *Implementing Packaged Software*. Retrieved from https://www.jstor.org/stable/249129?seq=1
Lucas et al. (2014). *Implementing Packaged Software*. Retrieved from https://www.jstor.org/stable/249129
Lynn, R. (2020). *Why Is Process Improvement Important?* Retrieved from planview.com: https://www.planview.com/resources/articles/why-process-improvement-important/
Lysons et al. (2019). *Purchase to Pay (P2P) Process*. Retrieved from https://www.cips.org/knowledge/procurement-topics-and-skills/ecommerce---systems/e-sourcing-- e-procurement-systems-p2p/purchase-to-pay-p2p-process
Massey, F. (2012). *The Kolmogorov-Smirnov Test for Goodness of Fit*. Retrieved from tandfonline: https://www.tandfonline.com/doi/abs/10.1080/01621459.1951.10500769
Metrejean et al. (2011). *The role of consultants in the implementation of enterprise resource planning systems*. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.476.1810&rep=rep1&type=pdf#page=9
Meyers et al. (2012). *The quality implementation framework: a synthesis of critical steps in the implementation process.* Retrieved from https://link.springer.com/article/10.1007/s10464-012-9522-x
Miles, J. (2005). *R Squared, Adjusted R Squared*. Retrieved from https://onlinelibrary.wiley.com/doi/abs/10.1002/9781118445112.stat06627
Minitab. (2013). *Regression Analysis: How Do I Interpret R-squared and Assess the Goodness-of-Fit?* Retrieved from https://blog.minitab.com/blog/adventures-in-statistics-2/regression-analysis-how-do-i-interpret-r-squared-and-assess-the-goodness-of-fit#:~:text=R%2Dsquared%20is%20a%20statistical,to%20the%20fitted%20regression%20line.&text=0%25%20indicates%20that%20the%2
Mishra et al. (2019). *Descriptive Statistics and Normality Tests for Statistical Data*. Retrieved from NCBI: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6350423/#:~:text=For%20the%20continuous%20data%2C%20test,used%20to%20compare%20the%20groups.
Mordkoff, T. (2016). *The Assumption(s) of Normality*. Retrieved from http://www2.psychology.uiowa.edu/faculty/mordkoff/GradStats/part%201/I.07%20normal.pdf
Morrison et al. (1992). *What enhances or inhibits learning a new job? A basic career issue.* Retrieved from https://psycnet.apa.org/doiLanding?doi=10.1037%2F0021-9010.77.6.926
Mortensen et al. (2017). *Making product customization profitable*. Retrieved from https://www.researchgate.net/publication/266890422_Making_Product_Customization_Profitable
Mujtaba et al. (2010). *Waste and Lead Time Reduction in a Software Product Customization Process with Value STream Maps*. Retrieved from https://ieeexplore.ieee.org/abstract/document/5475062
Ngwenyama et al. (1999). *New information technologies in organizational processes*.

Parr et al. (1999). *Identification of Necessary factors for successful implementation of ERP systems.* Retrieved from https://link.springer.com/chapter/10.1007/978-0-387-35566-5_8

Patanakul et al. (2009). *The effectiveness in managing a group of multiple projects: Factors of influence and measurement criteria*. Retrieved from sciencedirect.com: https://www.sciencedirect.com/science/article/abs/pii/S0263786308000392

Petrasch, R. (1999). *The definition of software quality - a practical approach*. Retrieved from https://www.researchgate.net/publication/258105237_The_Definition_of_'Software_Quality-_A_Practical_Approach

Petter, S. (2008). *Managing User expectations on software projects: Lessons from the trenches*. Retrieved from https://www.sciencedirect.com/science/article/pii/S0263786308000793

Piller, F. (2004). *Mass Customization: Reflections on the state of the concept*. Retrieved from https://link.springer.com/article/10.1007/s10696-005-5170-x

R Core Team. (2020). *R Language Definition*. Retrieved from https://cran.r-project.org/doc/manuals/r-release/R-lang.pdf

Ram et al. (2013). *Implementation critical success factors (CSFs) for ERP: Do they contribute to implementation success and post-implementaiton performance?* Retrieved from https://www.sciencedirect.com/science/article/pii/S0925527313000509

Randell, B. (1979). *Software Engineering: As it was in 1968*. Retrieved from https://www.researchgate.net/publication/221555451_Software_Engineering_As_it_was_in_1968

Rasch et al. (2007). *How robust are tests for two independent samples?* Retrieved from https://www.sciencedirect.com/science/article/pii/S0378375807000225

Rbloggers. (2019). *Explaining Predictions: Random Forest Post-hoc Analysis (permutation & Impurity variable importance)*. Retrieved from https://www.r-bloggers.com/2019/07/explaining-predictions-random-forest-post-hoc-analysis-permutation-impurity-variable-importance/

Rees et al. (2012). *Continuous organizational change and burnout*. Retrieved from https://www.researchgate.net/publication/288212932_Continuous_Organizational_Change_and_Bu rnout

Reich et al. (2010). *Roles of external IT project manager*. Retrieved from https://dl.acm.org/doi/abs/10.1145/1735223.1735254

Roser et al. (2002). *SHIFTING BOTTLENECK DETECTION* . Retrieved from https://ieeexplore.ieee.org/abstract/document/1166360

Rushton et al. (2010). *The handbook of logistics & distribution management*. Retrieved from https://www.academia.edu/28639307/The_handbook_of_Logistics_and_Distribution_ManageMent_5th_EDItION_Logistics_Distribution_MAnAgEMEnt_THE_HANDBOOK_OF_and_i

Saenz, M. (2018). *Building manufacturing flexibility with strategic suppliers and contingent effect of product dynamism on customer satisfaction*. Retrieved from https://www-sciencedirect-com.ezproxy.leidenuniv.nl:2443/science/article/pii/S1478409217300432

Sami, M. (2018). *5 Steps to Software Development Effort Estimation*. Retrieved from https://melsatar.blog/2018/01/15/5-steps-to-software-development-effort-estimation/

SAP. (2020). *What is ERP?* Retrieved from Insights.Sap.Com: https://insights.sap.com/what-is-erp/

Sauer et al. (2007). *The impact of size and volatility - On IT project performance*. Retrieved from Researchgate: https://www.researchgate.net/publication/220419735_The_impact_of_size_and_volatility_-_On_IT_project_performance

Schmidt et al. (2001). *Identifying Software Projects Risks: An international Delphi study*. Retrieved from https://www.tandfonline.com/doi/pdf/10.1080/07421222.2001.11045662?needAccess=true

SCMDojo. (2018). *6 Reasons why it is important to understand expected customer lead time*. Retrieved from https://www.scmdojo.com/understand-customer-lead-time/

Shin, H. (1996). *A process model of application software package acquisition and implementation*. Retrieved from https://www.sciencedirect.com/science/article/abs/pii/0164121295000453

Slinker et al. (1985). *Multiple regression analysis for physiological data analysis: the problem of multicolinearity*. Retrieved from https://journals.physiology.org/doi/abs/10.1152/ajpregu.1985.249.1.r1

Snapp, S. (2017). *How to plan long lead time vs short lead time items*. Retrieved from 2017, https://www.brightworkresearch.com/supplyplanning/2017/01/23/plan-long-lead-time-vs-short-lead-time-items

Soja, P. (2006). *Success factors in ERP systems implementations: Lessons from Practice*. Retrieved from https://www.emerald.com/insight/content/doi/10.1108/17410390610678331/full/html

Somers et al. (2001). *The Impact of Critical Success Factors across the Stages of Enterprise Resource Planning Implementations*. Retrieved from https://ieeexplore.ieee.org/abstract/document/927129

Statisticshowto. (2021). *F Statistic / F Value: Simple Definition and Interpretation*. Retrieved from https://www.statisticshowto.com/probability-and-statistics/f-statistic-value-test/

Statisticssolutions. (2020). *Sample Size Formula*. Retrieved from https://www.statisticssolutions.com/sample-size-formula/

SurveyMethods. (2014). *Extreme Response Bias*. Retrieved from https://surveymethods.com/what-is-extreme-response-bias/#:~:text=Extreme%20response%20bias%20is%20the,a%203%20or%20a%204.
Tayntor, C. (2007). *Six sigma software development*. Retrieved from https://books.google.nl/books?hl=en&lr=&id=TPE3rdP1lSwC&oi=fnd&pg=PP1&dq=software+package+six+sigma&ots=O_4vcens4M&sig=xc_wb0cqJf63BZVbHmhKzKakPII&redir_esc=y#v=onepage&q=software%20package%20six%20sigma&f=false
Umble et al. (2003). *Enterprise resource planning: Implementation procedures and critical success factors*. Retrieved from https://www.sciencedirect.com/science/article/pii/S0377221702005477
Vaidya et al. (2006). *Critical factors that influence e-procurement implementation success in the public sector*. Retrieved from http://ippa.org/jopp/download/vol6/issue-1-2/e_ProSympAr6_Vaidya_etal.pdf
Varadaraj, M. (2012). *Successful software adoption - A study of software implementation methodologies*. Retrieved from https://pdfs.semanticscholar.org/5b07/2da5a7ddaa6833abfa2947b5007bf789f9cd.pdf
Vogelezang et al. (2012). *Estimating Packaged Software Implementations: The First Part of a Framework*. Retrieved from https://www.researchgate.net/publication/260005848_Estimating_Packaged_Software_Implementations_The_First_Part_of_a_Framework
Winston et al. (2012). *The seven-step modelling process*. Retrieved from courselearn.net: https://lms.courselearn.net/lms/CourseExport/files/27d3c292-d17a-434a-ba6c-cf7260767779/Chapter_1.pptx
Zar, J. (2005). *Spearman Rank*. Retrieved from onlinelibrary.wiley.com: Https://onlinelibrary.wiley.com/doi/abs/10.1002/0470011815.b2a15150

Appendix

Appendix I: Abbreviations & Concepts

Account-manager: ProActive's Sales Representative

ASP: Application Software Package

Bottleneck: A critical point in the process that causes delays in the lead time of the process.

BPMN: Business Process Model and Notation

CSF's: Critical Success Factors

Customized software: Software developed for a specific customer

Delivery Template: An excel sheet the customer has to fill in before the consultant can configure the system, which for example contains the customer's organizational structure that has to be entered into the new system.

Demo Environment: A virtual demonstration environment of the product that the customer is going to implement, where the customer can test the different functionalities of the system by himself.

Desired Average Implementation Lead Time: The average implementation lead time when all the factors that influence the implementation lead time that can be influenced by the supplier are sufficiently dealt with.

EBIT: Earnings Before Interest and Tax

Exclusive Gateway: Notation in the BPMN modelling language that represents a decision moment in the process.

IDEA-Framework: Three steps: Identify, Evaluate, Act, to efficiently manage customer expectations

Implementation Success: Defined by ProActive as the level of customer satisfaction combined with how quickly the implementation was conducted.

Influenceable Factors: All the factors that influence the implementation lead time that can be influenced by the supplier.

Go-Live: The Go-Live happens when the customer rolls out the implemented module to all employees that are going to work with it.

Graduated Scale: Size of the Implemented Module at ProActive

Lead Time Distribution: The most important factors that influence implementation lead time, how these factors influence the lead time, and the specific impact of these different factors.

MSE: Mean Squared Error measures the average squared difference between the predicted values and the actual values.

Model: Visualized Overview.

Operationalization: Translating an abstract concept to make it measureable with data.

Software Package: A standard software system developed for a more general public

P2P: Purchase-to-Pay

Prototype: Defined in the context of the case study as either a demo environment or a referent.

Referent: A customer company that is already making use of ProActive's SPEND Cloud that is used in the implementation process with a new customer to enable the new customer to see how the SPEND Cloud can be used in a company similar to the new customer's company.

Response Bias: The response bias can occur when a question seeks for an answer that makes the respondent admit to an undesirable trait, leading to an unreliable answer.

SaaS: Software-as-a-Service

Software Lead Time Distribution: The most important factors that influence implementation lead time, how these factors influence the lead time, and the specific impact of these different factors.

Software Projects: Projects where a software system is being implemented.

Software Implementation: A systematically structured approach to effectively integrate a software based service or component into the workflow of an organizational structure or an individual end-user.

SPEND Cloud: ProActive's P2P Software Solution, consisting of five different possible modules: invoice processing, procurement, contract management, cash & card, and expense claims.

Software Quality: The existence of characteristics of a product which can be assigned to requirements.

SPI: Software Package Implementation

SQ: Sub-Question

Uninfluenceable Factors: All the factors that influence the implementation lead time that cannot be influenced by the supplier.

ZOHO: ProActive's CRM-System

Appendix II: Interview-request email

Dear Sir/Madam (Last Name),

My name is Rutger Kerckhoffs and I am studying ICT in Business at the university of Leiden. In the context of this study I am currently conducting a research on the successfactors of the implementationprocess of a Purchase-To-Pay solution. This research is focused on the solution that ProActive delivers, the SPEND Cloud.

From *(Consultant Name)* I heard that you as primary contact from *(Company Name)* underwent this implementation process with ProActive and to get a better understanding of how this process is experienced by a customer, I would like to ask you some questions about this process.

During the interview I would like to go through the different steps of the implementation process together, to get an idea of how the process exactly went; what you think went well or what you think could have been done better. The interview will take approximately one hour.

The interview can be conducted by telephone. Regarding the date and time, I would prefer to plan the interview as quickly as possible. Could you please indicate what is possible for you, regarding the planning of this interview?

If you have any other questions, feel free to contact me by phone or email. My telephone number is: XX-XXXXXXXX.

Thanks in advance and I am hoping for a quick response!

Kind regards,
Rutger Kerckhoffs

Appendix III: Question list Semi-Structured Interviews

Preparation: (Interviewee Name) from (Company Name) implemented the module invoice processing (and if applicable also <Module Name>) with an implementation lead time of X months. ProActive's consultant that was assigned to this project was (Consultant Name). Within six months after the implementation, the company called ProActive's support-desk X times.

1. To start off, I want to thank you for your time. I think it would be nice if we could do a short introduction first. My name is Rutger, I'm currently studying ICT in Business at the University of Leiden and for my graduation thesis I'm performing research on the success of the implementation process of a P2P product, more specifically the ProActive Spend Cloud. Could you tell something about your own background, how did you end up at (*Company Name)* and what exactly is your function?
2. Can you tell something about how you ended up choosing for ProActive?
    1. What did the situation before ProActive look like? Why change from this situation?
    2. How did you get in touch with ProActive?
3. What did you discuss in the first meeting with ProActive and why did you eventually choose for ProActive? Did you also look at other suppliers?
4. What did ProActive communicate before the intake? Did they provide you with information about the implementation process or only about the product? What information wasn't told that you would've liked to know before the intake?
5. What is your opinion on the communication between the first meeting and the start of the project (the intake)?
    1. Did ProActive prepare you for the intake?
    2. What went well in this phase of the process and what could have gone better?
6. Which stakeholders do you think are important to involve in the process?
    1. Were all these important stakeholders involved in the intake?
    2. Did all these important stakeholders think they were clearly informed about what was going to happen? No uncertainties?
7. Did ProActive give you the idea that they exactly understood what the problem was you wanted to solve with their P2P Solution?
    1. Did they communicate your requirements back to you and did this match your expectations?
    2. How did they communicate this back to you?
    3. Did you think both sides of the project had a clear image of what the priorities were?

4. Did the other stakeholders feel the same way?

8. What did you think about the intake meeting?
    1. What exactly did ProActive tell you in the intake?
    2. Did you get enough information out of the intake? Were there any surprises or was anything still unclear before or after the intake?
    3. How were these surprises or uncertainties resolved?
9. How do you think the transfer of the project from sales to consultancy went?
    1. How did the communication between the accountmanager and the consultant go?
    2. Were there any contradictions between what sales told you and what the consultant told?
    3. How did you like the collaboration with the accountmanager? Why?
10. Was it clear what ProActive expected from your side after the intake?
    1. What exactly did you think ProActive expected from you after the intake?
    2. Did you exactly know during the process who was responsible for what and who you could address when you'd need help?
    3. Did you also have a clear image of what you could expect from ProActive's side after the intake?
11. What did you think of the project planning?
    1. Do you think a tight planning is important in the implementation success?
    2. ProActive has some milestones in their planning (intake, delivery, configuration, training, pilot-phase, go-live, evaluation and project closure). How did ProActive communicate these milestones, were these milestones clear to you?
    3. Did this planning give you enough guidance? If not, what did you miss in the planning?
    4. How long did you think the process was going to take on forehand and how long did the process eventually take? In other words, did the planning appear to be a realistic one?
    5. What did you think of ProActive's role in the monitoring of the planning? Did someone even monitor the process?
    6. How did you think the overall communication in the process went (before, during and after the intake)?
12. → Summarize expectations on forehand, ask about specific milestone in planning where things were less clear, why that was the case, what went wrong, caused

problems, etc. Is there anything else you expected on the basis of the intake/pre-intake phase?

13. Looking back at it, is there anything you wish would have went differently in the process before the start of the implementation process? (the process until the end of the intake?)
14. How did ProActive live up to these expectations in the phase after the intake?
    1. How did you like the level of guidance from ProActive during the process after the intake?
    2. Was there anything you would have liked to happen differently?
15. After the configuration the training happened. What did you think of the training?
    1. A lot of things still unclear before the training?
    2. Were this things clear after the training?
    3. What did you like about the training and what did you not like about the training?
16. How did you experience the pilot-phase?
    1. Who started to work with the system at first?
    2. Did a lot of issues come forward in the pilot-phase?
    3. Were all these issues resolved eventually and how?
    4. How did you like ProActive's level of guidance during the pilot-phase?
    5. Do you think you had enough time to go through the pilot-phase?
    6. What did you like about the pilot-phase and what could have gone better?
17. How did the Go-Live phase go? What went well and what could've gone better?
    1. Who started to work with the system after the Go-Live?
    2. Did a lot of issues come forward after the Go-Live?
    3. Were all these issues resolved eventually and how?
    4. How did you like ProActive's level of guidance throughout the Go-Live phase?
    5. What do you think went well regarding the Go-Live and what could've been done better?
18. How do you think the overall adjustment from *(Company Name)* to ProActive went? Why did/didn't it go well?
19. Are you satisfied with how the process went?
    1. What were the positive points about the implementation process and what were things to improve?

2. Did the expectations you had on forehand match how the process eventually went?
3. How did the course of the project match the planning? Why do you think?
4. Would you still choose for ProActive, having in mind how the process went?
5. What did you think were the factors that had the most influence on the outcome of the project? Can you mention at least three?

20. How does *(Company Name)* work with ProActive nowadays? Is everyone satisfied about the system? How is the collaboration with ProActive as an organization nowadays?
21. Do you still have something to add? Did I forget to ask something still?
22. Do you still want to emphasize something? What is to you the most important thing we discussed in this interview?
23. Can I send you an email if I still want to ask something? Do you want to see the results of my research when it is finished? Also, you can always send me an email when something comes into mind! Thanks again for the interview!

Appendix IV: Interview Company's Case Descriptions

Company 1

The first interview was conducted with an employee from a broker company. This employee was responsible for the financial bookkeeping and salary processing of the company. The interview was held in person, in the building of Company 1. Company 1 operates in the Business Services industry.

In December 2018, Company 1 decided to start an implementation project with ProActive, because at that time the invoice processing process consisted of a lot of manual actions and the invoices had to go through a lot of different channels during the process. Also, at that time Company 1 did not have a central storage for the invoices, which meant it was hard for them to keep an overview of the invoices.

The employees of Company 1 were really open to a new way of working because the old way of processing invoices was relatively old fashioned, and thus they experienced very few resistance to the change to ProActive. Nevertheless, the lead time of the implementation process was above average: the lead time of this project was approximately eight and a half months. Furthermore, Company 1 conducted more than five times the amount of support-calls within six months after the implementation process was finished than average, which indicates that Company 1 had more difficulties adapting to the new system than average. At the same time, Company 1 is a company that is in the lowest scale in size, having 0-250 employees at the time of the implementation.

Company 2

The second interview was conducted online with an employee from an art-school. The interviewee in question was working at this organization as an application manager. Company 2 operates in the education-industry.

Before February 2018, Company 2 had several attempts where they tried to digitize their invoice processing process, but every time the project manager did not go through with it. Around the beginning of 2018, a new project manager arrived at the organization, who made the digitizing of this process one of Company 2's priorities. Before ProActive, Company 2 had to process the invoices on paper. As a result, Company 2 had no central place where the invoices were stored and the process had to go through way more different channels than necessary. This meant that the invoice processing process costed Company 2 more time and money than necessary, which made them decide to implement ProActive.

All different aspects of this project were around the average: the company had an average amount of employees (501-1000), needed an average amount of support calls (7) and had an average lead time of approximately five months.

Company 3

The third interview was held online with an employee from one of the biggest companies in Israel. Company 3 operates in the Business Services industry.

Although Company 3 has no activity in the Netherlands, their headquarters is located in the Netherlands. Company 3's top management is also working from Israel. The reason why Company 3 decided to go for ProActive is that they wanted to make all information regarding invoices available to every relevant party, which was difficult before the implementation, because of their unusual organizational structure. To achieve this, Company 3 was looking for a simple system that would not require complex processes. They ended up choosing for ProActive because, of all suppliers they contacted, ProActive was the one that had the shortest response time.

Even though Company 3 did not need an above average amount of support calls after the implementation and had a just below average amount of employees (251-500), this project had one of the highest lead times in the dataset: approximately twelve months.

Company 4

The fourth interview was conducted at the company building of Company 4, which was a company that operates in the Business Services industry. The interviewee was someone responsible for looking after the portfolio of Company 4's largest customers on the area of administration services and operational processes.

Company 4 is a company that specializes in advising non-profit organizations about their administration and operational processes. In this specific case, ProActive's solution was not implemented at Company 4 itself, but at one of their customer's organizations. Company 4 was the intermediary party between ProActive and this customer in the implementation process: Company 4 was responsible for the communication with ProActive and the introduction of ProActive's solution in their customer's company. For example, ProActive gave their general training to Company 4's employees, and these employees later on gave a more specified training to their customer's employees at the customer's organization.

Company 4's customer was looking for a system that was able to link with their financial system, Exact Online. Because ProActive had a lot of experience with making this link, Company 4 decided to choose for ProActive.

Everything about this project was 'better' than average: Company 4 is in the lowest category of company size (0-250 employees), required very few support calls (4) and the lead time of this project was approximately two months, one of the lowest lead times in the dataset.

Company 5

The fifth interview took place via a phone call with the head of finance from Company 5, an organization that takes care of the financial and personal administration of nine different school boards. Company 5 operates in the education industry.

Before ProActive, Company 5 was using a similar system called Simac. The downside of this system was that Company 5 had to pay for every update that was implemented within the system. Because of this, Simac became too expensive and they had to look for a similar system that was cheaper to use, which is how they ended up at ProActive.

Company 5 made an above average amount of phone calls to ProActive's support department within six months after the implementation, but he lead time of this project was below average; approximately four months. The organization has between 0 and 250 employees.

Company 6

The sixth interview was conducted online with the head of finance from Company 6, a company that operates in the healthcare industry.

Before the implementation actually started, the interviewee tried to change to a new financial system like ProActive for six years, but because of various causes Company 6 never went through with it. At last, Company 6 decided to go for ProActive in September 2018 because they wanted a central digitized archive for their invoices to be stored, and ProActive was the most user friendly system in their vision.

Company 6 is an organization with an above average size, having between 2001 and 4000 employees. They did not need one support call after the implementation was completed. The lead time of this project was approximately five months.

Appendix V: Summarized Interviews

None of the interviewed companies had a project where customization was required. Furthermore, only Company 1 and Company 3 implemented more than one module at the same time: they both implemented the procurement module, next to the invoice processing module.

Company 1

Company 1 implemented the SPEND Cloud based on the advice of their ICT-knowledge partner. Because of this, they did not look at other suppliers than ProActive after deciding to implement a P2P system. ProActive quickly convinced them of their system, partially because the situation where Company 1 came from was outdated.

The manager of the project from Company 1's side was a bookkeeper from their financial department, with a self-proclaimed small amount of affinity with IT. He stated that, because he had a very strict planning with tight deadlines, the initial configuration of the system went quickly. However, a lot of questions popped up after they started working with the system, because the system did not exactly deliver what he had expected beforehand. The interviewee stated that because of his little IT knowledge he did not know how to set up clear requirements on forehand and expected more help from ProActive's side in this. As a result, when they started working with the system for the first time, several changes had to be made to the system, which resulted in a longer lead time. Also, because Company 1 had different expectations from the system on forehand, they required a lot of support during the pilot-phase. The interviewee also stated that sometimes it took a long time before their questions were answered, which also lead to a delay in the project's end date. In hindsight, the interviewee expected more guidance from the supplier's side in terms of fitting the system into their organization. He stated that after the implementation he realized that ProActive's consultant has a very specific amount of tasks related to the implementation and ProActive does not really do anything outside of these tasks. However, he thought that organizations like Company 1, with lower IT knowledge, need more guidance than that. In spite of this, the interviewee was satisfied about the implementation, because Company 1's employees think the system is very user friendly, and the system solved a lot of issues they had in their previous situation.

Company 2

Company 2 took a long time to start with the implementation, because they wanted to prepare their requirements as good as possible. After a long process of looking at demo's from different suppliers, ProActive turned out to be the organization that had the best fitting solution for these requirements. However, the interviewee stated that not everything was as easy as it sounded in the demo. For example, Company 2 hired an external project-manager that had experience with similar projects, to plan and monitor the project. This external project-manager was also responsible for the delivery template of their organization, where things like Company 2's organizational structure had to be delivered to ProActive in order for them to do the configuration correctly. However, according to the interviewee, this external project-manager had no feeling with the organizational structure of Company 2 because he was not officially employed at Company 2. This resulted in extra work later in the process, because the delivery template has to be corrected to be able to make efficient use of the software solution. The interviewee also states that on forehand they did not know what kind of expertise was required for what part in the process, which resulted in some uncertainties later in the process. As the interviewee from Company 1 also stated, Company 2 expected more guidance from ProActive regarding fitting the system into the organization.

Overall, Company 2 was satisfied because they found the system very user friendly. Also, they stated that the assigned consultant was very skilled and easily reachable. The main point of improvement was that they would have liked to have more clarity about the required expertise and the division of roles, to be able to prepare better for the implementation process itself.

Company 3

Company 3's management gave the team that would be responsible for the implementation clear instructions that all they wanted was a quick win for a low price. The financial manager that was made responsible for the project choose for ProActive, because they were the quickest to respond to Company 3' request for implementation. Company 3 thus had little time available to prepare their requirements. This financial manager also stated he never did an IT implementation project before, and that he mainly did this project to learn about it.

During the intake, it seemed as if all Company 3' important requirements could be met, but the interviewee stated that "the real questions arise when you start working with the system". When they first started working with the system, the system turned out to not be as flexible as they expected on forehand. Also, the interviewee expected ProActive to help more with fitting the system into Company 3' organization and the planning of the project, but found out that the consultant only helped them on a technical level. Also because of this mismatch in expectations and reality, they also did not have a knowledgeable project-manager, which meant they also did not have a reliable planning to hold on to. All this resulted in a substantial delay of the implementation lead time.

Overall, the main point was that they needed more guidance than they eventually received. The main point of satisfaction was the response rate of ProActive, but the interviewee stated that ProActive only provides help passively.

Company 4

Company 4 is a company that carries out IT projects like the implementation of ProActive for their customers. Because of their experience with similar projects, they were able to set up a very detailed requirements-list that would lead them to the perfect supplier for their customer, which in this case turned out to be ProActive.

At the end of October, Company 4's customer made it very clear that they wanted to be live with the new system before the new year started. Therefore, the interviewee took the initiative to very tightly plan out and manage the project by himself, to be certain that this deadline would be met. Because all important stakeholders were very aware of this tight deadline, Company 4 managed to fully implement the new system before the start of 2019.

The interviewee stated that the project was finished so quickly mainly because of ProActive's high response rate and them making true what they promise on forehand.

However, the interviewee also stated that ProActive is not sufficient for all types of organizations, but that they were a good match with Company 4 because it was very clear what the division of roles was. This resulted in good communication and an efficient way of working.

Company 5

Company 5 operates in the education industry and, as the interviewee states, the organizations that operate in the education industry communicate with each other a lot. Company 5 choose to go for ProActive because they took a long time to prepare their requirements by looking at the systems that other similar organizations were using and ProActive came out of their 'research' as the most sufficient supplier. The interviewee states that this 'looking for reference' helped them really well in setting up their list of requirements.

The co-worker of the interviewee that carried out the project with him had implemented the SPEND Cloud in the previous organization he worked in, making it easy for Company 5 to know what to expect from ProActive. Next to this, Company 5 could use this previous organization as a reference to see how things work in the system when they needed to see it. Furthermore, the co-worker of the interviewee monitored the progress of the project, to make sure the deadlines would be met.

The interviewee stated that the experience of implementing similar systems and having a lot of reference to find out what they could expect from the system, together with ProActive's high response rate and the high level of user friendliness of the system, resulted in a relatively short lead time.

Company 6

Because the interviewee had six years of experience with trying to start an implementation with a company like ProActive, the list of requirements he had prepared was very detailed. Before making the decision to do the implementation with ProActive, the interviewee also went to other organizations similar to Company 6 to see what kind of P2P software they were using. Based on these extensive preparations, ProActive came forward as the most sufficient supplier.

The interviewee had over thirty years of IT project-management experience. For that reason, before the implementation started, he decided that he would manage the project for Company 6 and that ProActive would only have to guide him in a technical way. Because of the interviewee's experience in IT project-management, the clear division of tasks, clear communication and ProActive's high response rate, the lead time of the implementation was relatively short. However, the project suffered a minor delay because one of the departments from Company 6 had a different way of working than other departments, resulting in a miscommunication about what that specific department needed from ProActive. This had to be corrected later in the process, resulting in a longer lead time than the project could have had.

Appendix VI: Description of Steps in Process Model

Sales

Plan Demo meeting: Plan the introductory meeting with the customer.

Conduct Demo Meeting: Sales representative shows a demo to the customer and tries to convice the customer to choose for ProActive.

Add Prospect Information and set Status on 'Wait for Start': After the customer confirms they want to work with ProActive, the lead is put in the CRM system by sales. The name of the customer company, the main point(s) of contact from the customer company, the contact details of these point(s) of contact, the industry the customer company operates in[80], the module that is being implemented, the graduated scale of the module, the financial software that the customer has in use, and the amount of employees the customer company has are added to Zoho

Create new Quotation: After the customer has chosen which SPEND Cloud modules they want to implement, the account manager creates a quotation where the financial details of the proposed deal are incorporated.

Send new quotation to customer: After the quotation is set up, the customer has to agree on it before the contract can be set up.

Set up contract: Based on the quotation that is agreed upon, the sales representative has to set up the contract.

Acquire signatures: When the customer agrees on the quotation and the contract is set up, the account manager has to acquire the signatures of the sales director and the customer to be able to finish the contract.

Message Consultancy Team Leads about Project: When the contract is signed, the project can be transferred to consultancy through the CRM system (Zoho). It is the account manager's job to put all specific details he is aware of in Zoho, to make it possible for the consultancy to prepare the project as good as possible.

Conduct Intake: After the project is assigned to a consultant by one of the lead consultants, the final involvement of the account manager in the project is the intake. During the intake, the account manager officially hands over the project to the consultant that is assigned to the project. It is also a moment to confirm that everything the account manager said is also known and confirmed by the consultant.

Consultancy

Assign Consultant to Project: When the account manager hands the project over to consultancy, one of the lead consultants picks the project up and hands it over to one of the consultants (based on affinity and time leftover in the consultant's schedule). This information is put in Zoho.

Send Message About Consultant's Availability: To plan the intake session, the availability of the assigned consultant has to be shared with the customer.

---

[80] Education, Healthcare, Other Non-Profit, or Business Services

Conduct Intake: The consultant goes through the implementation site together with the customer and fills in the specific wishes and requirements of the customer. The consultant also sets up a planning for the project in consultation with the customer and shows the customer the documentation on the implementation site and where exactly it can be found.

Hand over project to consultancy: The intake session is the official moment when the project is handed over to consultancy, and the sales part in the project is over.

Summarize Intake: The consultant documents a summary of the intake and sends it to the customer to confirm their mutual agreements.

Send Intake Summary: The Consultant sends the intake summary to the customer.

Send Delivery Template: The delivery template consists of all necessary information (for example, the users with their specific roles within the system that need to be added to the system) and specific requirements the customer wants to see in the system. The consultant can only start configuring the system after a complete delivery template is received. Therefore, the consultant has to **check the delivery template** every time the consultant received it, because if it is not complete, problems will emerge later in the configuration phase. So, if the template is not complete, the consultant has to communicate this to the customer. Then, the customer can fill in the blanks so the consultant can start configuring the system.

Conduct Review Template Session: In the implementation of the largest graduated scale, an extra ‘review template session’ takes place, where the delivery template filled in by the customer is reviewed one additional time, to ensure that it contains no mistakes.

Notify Customer: When the delivery template is not complete, the customer has to be notified to fill in the template again.

Configure P2P System: After the consultant confirmed that the delivery template is complete, the configuration sub-phase can be initiated. In this phase, the consultant configures the system according to the delivery template. When the configuration of the system is complete, a training can be planned conform the planning made in the intake.

Conduct Design Session: When implementing the procurement module, a design session is conducted because the procurement module is an overall more complex module. In this design session, the consultant shows the different results of certain configurations, to more gradually show the customer how the system works.

Give administration training: When the procurement module is not implemented (or the design session has already taken place), the administration team training is conducted by the consultant. In this training, the specific set of customer-employees that ProActive closely underwent the implementation with get to see their specific P2P system for the first time. This is also a session where this specific group of employees can ask some final questions before the general training.

Give general training: After the administration training, on the same day, the consultant conducts the general training. In this training, a larger group of customer-employees is in the audience. A representative group of each department that is going to work with the system is present during this training. This enables every department to come up with department-specific questions, to be able to make it easier for every different function in the customer company to start working with the system.

Pilot-phase: After the general training, the pilot-phase is initiated. In the pilot-phase, the representative group of customer-employees gets to work with the SPEND Cloud for the first time. The pilot-phase is started off when the consultant sends the customer **test scripts** and provides the customer with a **test-environment**.
The consultant's role in this pilot-phase is to passively answer the questions that the customer comes up with. When the customer indicates he is ready to go live, the consultant can either approve or reject this indication. However, a rejection is only given in big exceptions. The pilot-phase ends with the consultant's approval.

Help Customer with Go-Live: If the first implementation type is not applicable, the consultant goes to the customer's company to aid them with rolling the system out to the full organization.

Start Subscription: After the pilotphase, the system is rolled out to the rest of the customer-organization. This also means the subscription of the customer starts, which means they have to start paying ProActive for making use of their system, according to the contract-terms they signed for before the intake.

Hand over project to support: Since the consultant is only supposed to be involved in the implementation-process, the consultant hands over the project to Support Consultancy. They change the project status in Zoho and they inform both the customer and the Support department that the consultant's part in the project is done.

Plan evaluation session: To put a formal end to the project, the consultant, in consultation with the customer, plans an evaluation session to evaluate how the implementation process went. The important findings of these sessions are documented by the consultant. This step only occurs if the third- or fourth implementation type are applicable; in the first- and second implementation types, the evaluation is conducted by phone or on-site, immediately after the Go-Live.

Close project: After the evaluation session, the implementation process is officially over.

<u>Development</u>

Customization: In every invoice processing module implementation, a connection has to be made between this customer's financial system and ProActive's system, to make sure the two systems are synchronized. This is required because without this connection, optimal use of ProActive's system is not possible. However, when this connection is not a connection that has been made by ProActive before, it has to be created by ProActive's development department. In other words, when this connection has been made before, ProActive can reuse this earlier used connection. However, when it is a connection ProActive has never made before, their development department has to make this new connection possible, which means customization is required.

Appendix VII: Sub-Sample Set

Company 1 to 6 are the interviewed cases, company 7 to 23 are the survey respondents.

Interview & Survey cases

Case Company	Prototype Available?	SufficienT Requirement Preparation?	Sufficient Project Manager?	Experience with Similar Implementations?	Employees with sufficient IT-knowledge?	Sufficient Resource Allocation?	Expectations in line with (supplier's) reality?	Implementation Lead Time
Company 1	No	No	No	No	No	No	No	8.5
Company 2	Yes	Yes	Yes	Yes	Yes	Yes	Yes	5
Company 3	No	No	No	No	No	No	No	12
Company 4	Yes	Yes	Yes	Yes	Yes	Yes	Yes	2
Company 5	Yes	Yes	Yes	Yes	No	Yes	Yes	4
Company 6	Yes	Yes	Yes	Yes	Yes	Yes	No	5
Company 7	Yes	Yes	Yes	Yes	Yes	Yes	Yes	3
Company 8	Yes	Yes	Yes	Yes	Yes	Yes	No	5
Company 9	Yes	Yes	Yes	Yes	Yes	No	Yes	9,5
Company 10	No	Yes	Yes	No	Yes	No	No	5
Company 11	Yes	Yes	Yes	Yes	No	Yes	Yes	6
Company 12	Yes	Yes	Yes	Yes	Yes	Yes	Yes	4
Company 13	Yes	Yes	Yes	Yes	Yes	Yes	Yes	5
Company 14	No	Yes	Yes	No	Yes	Yes	Yes	6
Company 15	No	Yes	Yes	No	Yes	No	Yes	8
Company 16	Yes	Yes	Yes	Yes	No	Yes	Yes	3
Company 17	Yes	Yes	Yes	Yes	Yes	No	Yes	9
Company 18	Yes	Yes	No	No	Yes	No	No	15
Company 19	Yes	Yes	Yes	No	Yes	No	Yes	13
Company 20	No	No	Yes	No	No	No	No	5
Company 21	Yes	Yes	Yes	Yes	No	Yes	Yes	6
Company 22	Yes	Yes	Yes	No	No	No	No	10
Company 23	Yes	Yes	Yes	Yes	No	Yes	No	5.5

Appendix VIII: Survey questions

Note: The highlighted text shows for what (potential) factor that influences implementation lead time the question was asked.

1. What company did you work for when you underwent an implementation with ProActive?
2. On forehand, we knew exactly what we wanted to achieve with the implementation of the Spend Cloud. (strongly disagree, disagree, neutral, agree, strongly agree) ***Sufficient Requirement Preparation Yes/No***
3. Could you briefly indicate why you decided to choose for ProActive? ***Sufficient Requirement Preparation Yes/No***
4. How did you prepare for the implementation of the Spend Cloud? ***Sufficient Requirement Preparation Yes/No***
5. On forehand, we knew exactly what ProActive expected from our side and what we could expect from their side. (strongly disagree, disagree, neutral, agree, strongly agree) ***Expectations in line with reality Yes/No***
6. Were things realized in a different way than what you wished how it would be realized on forehand? If yes, what was realized differently? ***Expectations in line with reality Yes/No***
7. Before/during the implementationprocess, we had the possibility to test the usage of the ProActive module (for example by being in contact with a similar organization that was already using the Spend Cloud, or a demo environment) ***Prototype Available Yes/No***
8. In what way could you experience this usage? ***Prototype Available Yes/No***
9. We had a clear image of the possibilities of the Spend Cloud (strongly disagree, disagree, neutral, agree, strongly agree). ***Expectations in line with reality Yes/No***
10. How did ProActive help to create this clear image? ***Expectations in line with reality Yes/No***
11. If not, what was missing? ***Expectations in line with reality Yes/No***
12. During the implementation process, we had a planning with tight deadlines that was clear to everyone involved (strongly disagree, disagree, neutral, agree, strongly agree). ***Tight Planning Yes/No***
13. If not, did this and where did this cause problems? ***Tight Planning Yes/No***
14. The progress of this planning was tightly managed by our project manager (strongly disagree, disagree, neutral, agree, strongly agree). ***Tight Planning Yes/No***
15. Was this project manager experienced with similar implementation projects? (very, medium, little) ***Experienced with similar implementations Yes/No***
16. How would you estimate the level of IT-knowledge of the employees from the company where you worked during the time of the implementation? ***Sufficient Employee IT-Knowledge High/Medium/Low***
17. Did you experience a lot of resistance from within the company when the system was being implemented? ***Sufficient Employee IT-Knowledge Yes/No***
18. Why do you think that is? ***Sufficient Employee IT-Knowledge Yes/No***
19. In all steps of the project, the required expertise was present in the right places (strongly disagree, disagree, neutral, agree, strongly agree). ***Sufficient Resource Allocation Yes/No***
20. Where not? ***Sufficient Resource Allocation Yes/No***
21. What caused this? ***Sufficient Resource Allocation Yes/No***
22. Did this cause any problems and why? ***Sufficient Resource Allocation Yes/No***

23. ProActive's communication before the project started was in line with how the implementation eventually was conducted (strongly disagree, disagree, neutral, agree, strongly agree). ***<u>Expectations in line with reality Yes/No</u>***
24. If not, what was the consequence of this? ***<u>Expectations in line with reality Yes/No</u>***
25. ProActive had a high response-rate (strongly disagree, disagree, neutral, agree, strongly agree).
26. ProActive supported us during the implementation as we expected on forehand (strongly disagree, disagree, neutral, agree, strongly agree). ***<u>Expectations in line with reality Yes/No</u>***
27. Did something go different and why? ***<u>Expectations in line with reality Yes/No</u>***
28. What do you think is the most important reason that the process went as it went? ***<u>This question emphasizes a particular cause</u>***
29. Are there any other things you would like to share about the implementation projects?

Appendix IX: Normality Tests

Group of Projects	**Normality Test**
First time connection with customer's financial system	p = 0.062197
Existing connection with customer's financial system	N > 30
Assigned consultant with less than half a year of employment at ProActive	N > 30
Assigned consultant with more than half a year of employment at ProActive	N > 30
Projects with an above average amount of support used within six months of the end date of the implementation	N > 30
Projects with a below average amount of support used within six months of the end date of the implementation	N > 30
Projects where the first implementation type based on graduated scale was applicable	N > 30
Projects where the second implementation type based on graduated scale was applicable	N > 30
Projects where the third implementation type based on graduated scale was applicable	p = 0.51622
Projects where the fourth implementation type based on graduated scale was applicable	p = 0.76088
Invoice-processing module implementations	N > 30
Procurement-module implementations	N > 30
Contract-management module implementations	N > 30
Projects where multiple modules were implemented at the same time	N > 30
Projects where only the invoice processing module was being implemented	N > 30
Projects with a deadline close to new year's eve (1 month margin)	N > 30
Projects without a deadline close to new year's eve (1 month margin)	N > 30
Projects with customers that operate in the business services industry	N > 30
Projects with customers that operate in the healthcare industry	N > 30
Projects with customers that operate in the education industry	N > 30
Projects with customers that operate in the non-profit industry	p = 0.06752
Projects with an end date in January	p = 0.21672
Projects with an end date in February	p = 0.12024
Projects with an end date in March	p = 0.15862
Projects with an end date in April	p = 0.05092
Projects with an end date in May	p = 0.40489
Projects with an end date in June	p = 0.53789
Projects with an end date in July	p = 0.06264
Projects with an end date in August	p = 0.17437
Projects with an end date in September	p = 0.68314
Projects with an end date in October	p = 0.18597
Projects with an end date in November	p = 0.58608
Projects with an end date in December	p = 0.36481

Appendix X: Spearman Correlation Example

Zar (2005) describes Spearman Correlation as follows: first the data from each different group is ranked, where the lowest value has the lowest rank and the highest value has the highest rank. Then, per piece of data in the dataset, the ranks of the two different variables that are related to every piece of data are multiplied with each other. Hereafter, the sums of the ranks of the first variable (X), the ranks of the second variable (Y), and the multiplied ranks (XY) are calculated. The '*Spearman Correlation Coefficient'* (R) is then calculated by using the following formula:

$$R = \frac{XY - \frac{(X)(Y)}{N}}{\sqrt{(\sum X^2 - \frac{X^2}{N})} * \sqrt{(\sum Y^2 - \frac{Y^2}{N})}}$$

Where N is the amount of values in each different group, X is the sum of the ranks of the first variable, Y is the sum of the ranks of the second variable, and XY is the sum of the multiplied ranks. This formula results in a R that is between -1.00 and 1.00, where 1.00 is a perfect positive correlation and -1.00 represents a perfect negative correlation.

For example, when our complete dataset would be ranked as in table 12, XY in the formula would be 56, X would be 21, Y would also be 21, and N would be 6. $\sum x^2$ would then be $6^2 + 5^2 + 4^2 + 3^2 + 2^2 + 1^2 = 91$, and $\sum y^2$ would then be $1^2 + 2^2 + 3^2 + 4^2 + 5^2 + 6^2 = 91$. Filling these values in in the formula would result in a Spearman Correlation Coefficient of -1.00, which means these two variables X and Y have a perfect negative correlation.

Table 12: Spearman Correlation Dataset Example

Project	**Variable X Rank**	**Variable Y Rank**	**XY Rank**
Project 1	6	1	6
Project 2	5	2	10
Project 3	4	3	12
Project 4	3	4	12
Project 5	2	5	10
Project 6	1	6	6
Sum of Ranks	**21**	**21**	**56**