Evaluating future IT-investment options through technology debt

- A case study and theory testing approach on Company AB

Bachelor thesis in Business Administration
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Abstract: Evaluating future IT-investment options through technology debt
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Background and problem: Due to the increasing investments in Information Technology (IT) a larger portion of companies experience consequences of past decisions. IT-systems are not always easily replaced due to their critical functions. This causes path dependency and potential lock-in(s), which causes problems for a future decision-maker. A recently proposed theory takes this into account and proposes a method for evaluating technology related investments. This thesis aims to provide a theory test through a case study in order to identify its possible applicability on future investments, regarded as real-options. The thesis is thus guided by the following research question (RQ):

RQ: How can technology debt be used when a company evaluates future IT-investment options?

Objective: The objective with this thesis is to test the theory of technology debt on future IT-investments in a company, and evaluate its usability. Three clear questions arose that needed research to carry out the objective: *How can technology debt be applied to future IT-investment options? How can technology debt support the choice between future IT-investment options? How is technology debt relevant to decision-makers when facing IT-investment options?*

Method: In order to answer the three questions above, three studies were carried out. The purpose of study 1 was to answer: *How can technology debt be applied to future IT-investment options?* In order to accomplish this, an expansion of the original framework was conducted. Study 2 operationalized the results from study 1 through a case study on a company's two possible future IT-investments. The purpose of the case study was to examine if technology debt could be used to support the choice between future IT-investments option. The case study involved nine qualitative interviews on a company's staff in order to pinpoint the consequences on future decisions. The results from study 2 were subsequently evaluated through study 3. A discussion with the company's CFO/CIO was conducted with the purpose to see if technology debt is relevant to decision-makers when facing IT-investment options.

Results: Study 1, the theory of technology debt can be applied on future IT-investments through categorization and measurement of future lock-ins. Study 2, different future IT-investments can be compared using real-option theory, where each IT-investment's technology debt is measured. The option that gives the highest future maneuverability should be recommended because this option results in the lowest amount of future (switching-) costs. Study 3, technology debt is relevant to decision-makers as it is able to capture the long-term effects in terms of future lock-ins for a future decision-maker, and serve as a complement to other measurements, such as implementation costs etc.

Keywords: Decision-making, lock-in, technical debt, technology debt, IT-systems, IT-governance, theory testing, investment options, real-options, path-dependency

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1. Introduction

The introduction will start off with a background to Information Technology(IT-)investments and how IT-investments can lead to something called path dependency. Various relevant concepts and theories will be briefly explored. Thereafter an explanation on how the metaphor technical debt evolved and gave birth to the theory of technology debt is followed by a short introduction to the term technology debt. Then the thesis' objectives and research question are presented. Finally a short disposition of this thesis is given.

1.1. Background

Before the new millennia, corporations spent vast resources on their Information Technology (IT-)systems. Then the burst of the IT-bubble transpired and spending dropped significantly, however, since then investments have resurged (McAfee, 2012). In the U.S. economy, private investments in IT have more than doubled and the relative increase in IT-systems and software has experienced an even more substantial increase during 1992-2012 (Bureau of Economic Analysis, 2012). Venkatraman and Shantapriyan (2013) find that today IT is an important part of corporations and the IT budget accounts for 30-50% of their annual capital expenditure. They classified IT-expenditures into two types; investing in new IT-infrastructure and costs to keep the systems maintained thereafter. According to their findings around 46% of the budget is spent on new investments and the decision-making-value of these investments also becomes questioned soon after implementation. Various studies show that IT does contribute to improved productivity, higher profitability, and enhanced customer satisfaction (Dewan and Ren, 2011; Mithas et al., 2012; Ramirez, Melville, and Lawler, 2010; Ravichandran and Lertwongsatien, 2005). These contributions are aligned with management's ability to steer the investments in a desired direction, thus creating/adding business value. Subsequent increases in business value are vital to the future of the corporation (Bacon, 1992; Yayla and Hu, 2011; Reinhard, 2012; Kohli, Devaraj, and Ow, 2012).

Investing in new infrastructure combined with previous investments accumulate into something referred to as an installed base (Bygstad, 2010; Hanseth, 2002). Corporations are then constrained and limited by these systems in their ability to act, yet they are vital for their operations (van Oosterhout, Waarts, and van Hillegersberg, 2006; Lu and Ramamurthy, 2011). Greater investments in IT can lead to unintended technology traps over time (Grover and Malhotra, 1999). As firms increase their investments in IT inadvertently positive effects occur and a technological path is established. Subsequent investments thus enable firms to build on prior IT-infrastructure (an installed base if you will) in further changes to their IT-infrastructure. Prior investments tend to keep you on the established technological path; this phenomenon goes by the name of path dependency (Arthur, 1994; Kim and Sanders, 2002; List, 2004). Typewriters exemplify path dependency in an apparent way. The QWERTY-standard is well known not to be optimal for writing, yet it is used everywhere as a consequence of dependency caused by previous investments (Page, 2006; Magnusson and Bygstad, 2014).

As previously noted, IT is considered vital to corporations, although its payoffs, not necessarily in monetary terms, are not as undisputed (Brynjolfsson, 1993; Macdonald, Anderson, and Kimbel, 2000; Carr, 2003). Path dependency trails into another concept called lock-in(s). Lock-in(s) occur(s) when the switching costs to implement a new technology exceeds the profits of the implementation (Shapiro and Varian, 1999). Another definition is: "*Switching cost is typically defined as the disutility a customer experiences in switching products or product providers.*"

(Chen and Hitt, 2005, p.4). A typical example of this is the case of Bell Atlantic and AT&T, where AT&T installed their products in order to update Bell Atlantics telephone system to the modern age. This was done in a way so that Bell Atlantic could not perform maintenance themselves. By doing this AT&T forced Bell Atlantics to keep investing in the laid out path because the switching costs for Bell Atlantic would be too significant (Shapiro and Varian, 1999; Farrel and Klemperer, 2005).

Certain lock-ins in IT-investments links to the metaphor of technical debt. Ward Cunningham coined this metaphor in his report "*The WyCash Portfolio Management System*"(1992). He described how programmers sometimes ship incomplete code as they deem it easier to meet the deadline and fix it afterwards rather than taking the time to write 'perfect' code (Cunningham, 1992). Reasons for incurring technical debt are many and by definition not all bad, according to Allman (2012). Technical debt occurs, or is taken on intentionally, when programmers diverge from established best practices in order to deliver a product that is good enough instead of what they know to be optimal (Tom, Aurum, and Vidgen, 2013; Allman, 2012). Combining technical debt with finance theory infers certain implications on consequences of technical debt (Allman, 2012). The three properties of going into financial debt are the following; first, it is supposed to be repaid eventually; second, it is supposed to be repaid with some kind of interest, meaning more than the original loan; third, if you cannot pay back for some reason, there will be a very high cost, "*...be it declaring bankruptcy, losing your house, or (if you borrowed from the wrong person) a long walk off a short pier wearing cement shoes.*" (Allman, 2012, p.1). However, unlike financial debt, technical debt almost never have to be repaid completely as it remains in the organization (Allman, 2012), as its technological heritage (Magnusson and Bygstad, 2014).

Based on technical debt and technological heritage a newly proposed theory named technology debt has been developed by Magnusson and Bygstad (2014). Technology debt is defined as: *"Accumulated obligation owned by current CIO (debtor) to future CIO (creditor), where previous decisions limit prospective decisions"* (Magnusson and Bygstad, 2014, p.6). This theory aims at identifying technology debt to support decision makers in evaluating IT-investments. A typology has been developed to classify technology debt and to pinpoint the limitations caused by previous investments in IT-infrastructure (Magnusson and Bygstad, 2014).

In this thesis the theory of technology debt is applied on a company who are in possession of two future investment options. Real-options have been proposed as a method for evaluating future IT-investments (Balasubramanian, Kulatilaka, and Storck, 2000). More specifically a real-option approach is required:

1. *"When there is a contingent investment decision. No other approach can correctly value this type of opportunity.*
2. *When uncertainty is large enough that it is sensible to wait for more information, avoiding regret for irreversible investment.*
3. *When the value seems to be captured in possibilities for future growth options rather than current cash flow.*
4. *When uncertainty is large enough to make flexibility a consideration. Only the real options approach can correctly value investments in flexibility.*

5. *When there will be project updates and mid-course strategy corrections."* (Amram and Kulatilaka, 1998, p 24; Schulmerich, 2010, p.24)

Thus the thesis incorporates theories regarding future investments, mainly real-option theory, as it views the decision the company faces as two investment (real-)options. Noteworthy is that the purpose is not to value these two options in monetary terms, just their future level of technology debt. Real-option theory also includes other possible options, such as doing nothing, yet in this case study only two investment options are evaluated, as this is the situation described by Company AB.

1.2. Research question

With the presented background the overarching research question (RQ) is proposed as a way to test the applicability of this newly proposed theory concerning technology debt. It has not previously been thoroughly tested and the contribution of this thesis is to research its usage on selection between future investment options.

RQ: How can technology debt be used when a company evaluates future IT-investment options?

Thus the objective of this thesis is to test the theory of technology debt on future IT-investment options, through a case study, and evaluate its decision-making-value. This is further operationalized through the following three questions:

1. *How can technology debt be applied to future IT-investment options?*

2. *How can technology debt support the choice between future IT-investment options?*

3. *How is technology debt relevant to decision-makers when facing IT-investment options?*

1.3. Background to Company AB

The company that the theory is tested on is referred to as Company AB, as they choose to be anonymous. Company AB is a medium-sized enterprise with approximately 140 employees. They have an annual turnover of three billion Swedish kronor. Together with 500-600 external entrepreneurs they have various IT-systems for communication and management-control. Many of these systems have been developed in-house as they identified a specific/new need. The company is a subsidiary within a large international corporation. Ten employees work primarily with the IT-infrastructure and surrounding systems. (Interview 7a)

1.4. Outline

The structure of this this thesis is the following. To start off there is a short introduction to IT-investments and technology debt; this is to build a common foundation for the reader as they delve further into this research. Then the research approach and its process are reviewed and arguments regarding the procedures are countered. Also the various steps conducted in the process are described in detail, together with some tables regarding the literature review and

interviews. Ethical considerations and an information evaluation are also discussed. The focus of this section is to make the results as reproducible as possible, by presenting the process with a credible representation of policies underlying the choices. Subsequently, previous research concerning IT-infrastructure, IT-governance, technological constraints, technology debt, and real-option theory are reviewed. The results are divided into three sections following the three studies that were conducted. These results are then discussed with the purpose of answering the three questions. These answers together form an answer to the RQ, combining previous research with the empirical findings of the case study. Finally, a conclusion, including the implications for practice and research as well as suggestions for further research, is offered before the list of references.

2. Method

The method will first show the reasoning concerning the approach taken in this thesis. After this the research process is described thoroughly. The course of action in the three studies is presented to increase the reproducibility of the results. The section that follows contains a discussion regarding the ethics in business research and taken considerations. The method concludes with an argumentation of the trustworthiness and authenticity of this thesis and the criticism of the underlying sources.

2.1. Research approach

This thesis took a deductive approach regarding the theoretical and empirical findings. A deductive approach is generally used to test the validity of a hypothesis or research question based on theoretical studies (Merriam and Nilsson, 1994). Case studies are suitable when answering research questions that consist of "how" and "why" characteristics (Yin, 2009), and also when answering questions of the "what" nature (Ghauri, 2004). There is criticism regarding case studies' lack of rigor (Lutz, 1989), and that the theory cannot be generalized on a larger sample based on one single case study (Johnston, Leach, and Lie, 1999). However, there are studies claiming that a theory can be generalized through a case study (Hillebrand, Kok, and Biemans, 2001; Modell, 2005). The process to achieve rigidness through validity within the case study will be presented below.

Since the theory of technology debt is newly proposed (2014) this thesis will serve as a theory test. Theory testing is particularly appropriate when a study suggest the addition of a new perspective, since it is based on new empirical data instead of prior empirical knowledge (Eisenhardt, 1989).

2.2. Research process

This section will describe the various steps taken in order to answer the three questions presented above, as an operationalization of the RQ. Readers can use this section as an illustration of how various steps in the research process were evaluated and selected. In figure 2.1 below there is a visual representation of the research process.

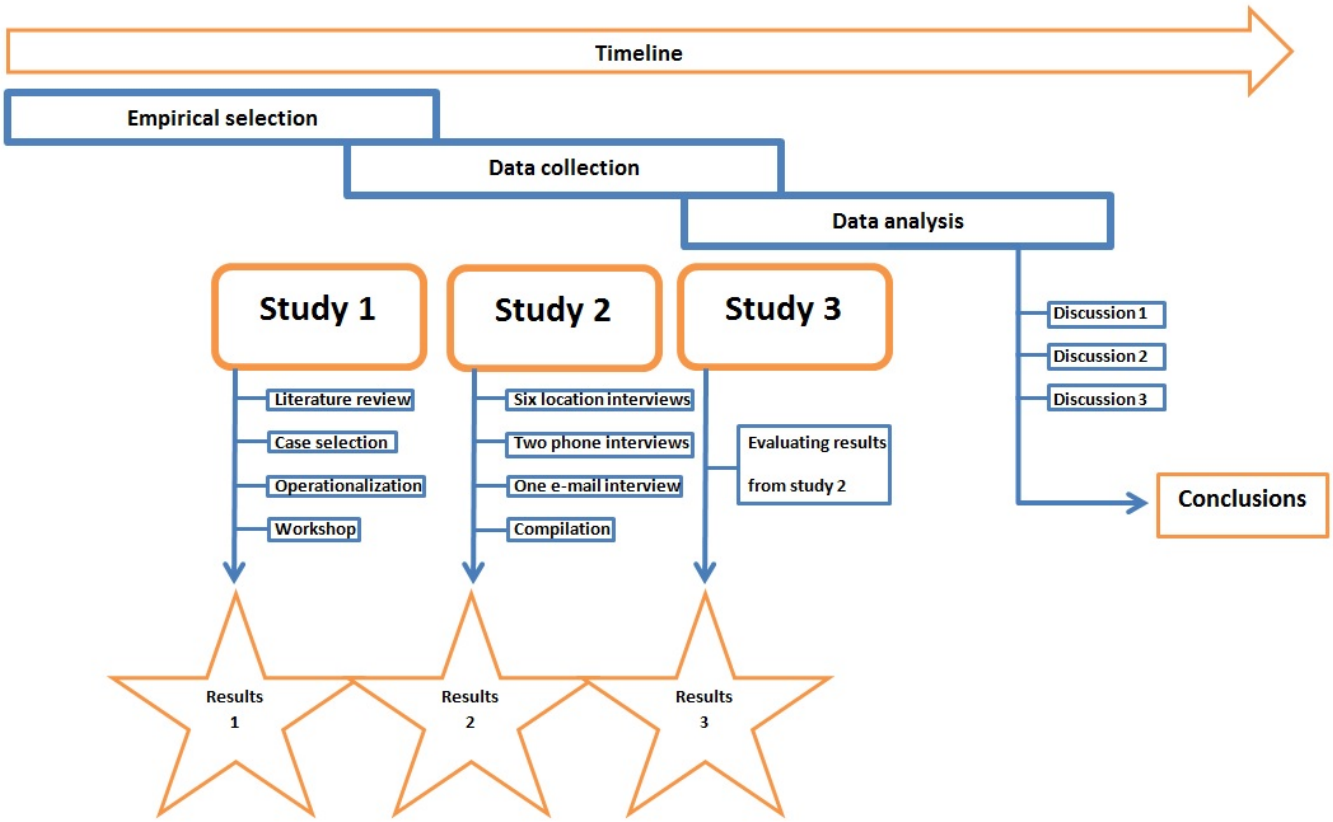

Figure 2.1 Research process

2.2.1. Study 1 (Pre-study)

In order to answer the question "*how can technology debt be applied to future IT-investment options?*" a pre-study was carried out. The process is explained below.

Owing to contact with one of the authors of the article "*Technology debt: Toward a New Theory of Technology Heritage*" a previously untested application of the theory, developed in the article, was identified. The idea was to test the theory on future investments. In order to do this a case study was deemed appropriate. Our supervisor assisted us in establishing contact with a company that faced the selection between two future IT-investments.

In order to gain knowledge within the field of IT, a literature review regarding IT-investments and real-option theory was conducted. This review focused on articles since the theory and its components are relatively new and books tend to lag due to the publishing-progress taking a lot of time (Patel and Davidson, 2003). To search for articles two search-engines were used, Google Scholar(GS) and Business Source Premier(EBSCO). The articles were sorted by "relevance". Abstract of the 50 first hits in each search-engine were read. Articles that came up more than once were substituted by a new article. The results from this search are presented in table 2.1. Articles deemed relevant were added to the thesis. To complement the review, articles and books from the original article regarding technology debt by Magnusson and Bygstad (2014) were examined and used. Other articles were found by specific search-terms referenced in the original literature review, such as "Real-option theory" or "IT-governance". Finally, articles recommended by our supervisor were read and included when appropriate.

Database	Term	Date of search (M/D/Y)	Total hits (GS/EBSCO, Max: 50)	Articles fully read (GS/EBSCO)
GS/EBSCO	"Technology debt"	4/3/14	50/3	1/0
GS/EBSCO	"Technical debt"	4/3/14	50/35	11/0
GS/EBSCO	"IT-systems"	4/3/14	50/50	8/1
GS/EBSCO	"IT-management"	4/4/14	50/50	7/5
GS/EBSCO	"IT-governance"	4/4/14	50/50	10/7
GS/EBSCO	"IT-governance" AND "lock-in"	4/7/14	50/0	5/0
GS/EBSCO	"Real-option Theory" AND "IT-investments"	4/25/14	50/0	9/0
GS/EBSCO	"Real-option Theory"	4/25/14	50/50	15/2

Table 2.1 Literature review

During the first meeting with the CFO/CIO (s)he explained how the business was organized and offered a thorough explanation of the decision the company was facing. A rudimentary timeline was proposed, however specific details were left to the workshop. How the theory in collaboration with this thesis could lay as a foundation for the impending decision was also discussed.

In order to operationalize the theory of technology debt on future IT-investments, an expansion of the original typology and each of its categories was conducted. This expansion lead to the results presented in 4.1, and answers how to apply technology debt to future IT-investment options. The analysis of the results of study 1 is presented in 5.1.

Before conducting the second study, a workshop was carried out with the CFO/CIO of Company AB. The reasoning behind this was to receive feedback on the developed questionnaire. During this workshop (s)he suggested that the typology lacked one aspect, autonomy, the company's ability to act as an autonomous business unit. This aspect was added to the questionnaire.

2.2.1.1. Case selection

The case study will examine Company AB's two alternative future IT-investments, Investment Option 1 (IO1) and Investment Option 2 (IO2). IO1 and IO2 does not cover the whole IT-system within Company AB, there are also external interfaces and modules. IO1 is an updated version of Company AB's current Enterprise Resource Planning (ERP-)system. IO2 is a more extensive ERP-system that includes more functions than the current ERP-system. Worth noticing is that IO2 will be implemented according to a template that is developed by the parent company of the corporate group, meaning that it is not tailored to Company AB or the specific circumstances surrounding the industry in which Company AB is active (Interview 7a).

2.2.1.1.1. Validity of the case study

In order to achieve rigidness through validity within this case study, three different criteria will be evaluated; external validity, internal validity, and construct validity (Modell, 2005).

To achieve external validity within this case study, the results of the case study should be able to be generalized across populations (Modell, 2005). In order to enhance the external validity, a theory can be extended through refinement of the explanations of the theory (Modell, 2005). During the process of operationalizing the theory of technology debt, an expansion within its original typology was conducted. Stemming from this, the RQ and the theory were tested on one case. This process lead to further theory definitions as presented in 4.1. and through this external validity was enhanced.

Internal validity examines the causal relationships between the independent variable(s) and the dependent variable(s) within the case study (Modell, 2005). A threat to achieving internal validity would be if the results from the causal model are under- or mis-specified (Modell, 2005). Through the expansion of the original framework a questionnaire was created to measure the technology debt incurred through the two alternative investment options. Since this questionnaire was based on a framework, see 4.1., the problem presented above would not occur and an internal validity would be achieved.

In order to achieve construct validity within a case study, an evaluation of the results should be conducted (Modell, 2005). The results from the evaluation with the CFO/CIO in Company AB are presented in 4.3. This evaluation accomplished construct validity for the case study since feedback to the relevance of the theory and the developed framework was given.

2.2.2. Study 2 (Interview-study)

The case study involved nine qualitative interviews. These were the interviews offered by Company AB. It is more valuable to conduct a few thorough interviews rather than numerous general interviews (Trost, 2005). These interviews are presented below in table 2.2.

Interview:	Interview type:	Length of interview:	Date:	Age:	Years at Company AB:	Years at current position:	Professional title:
1	Visit	38:36 min	2014-04-30	54	11	2	System developer
2	Visit	32:57 min	2014-04-30	50	5	5	Accounting Manager
3	Visit	35:12 min	2014-04-30	42	7	7	Controller
4	Visit	38:36 min	2014-04-30	44	2	2	System developer
5	Visit	40:28 min	2014-04-30	56	27	14	System administrator
6	Visit	33 min	2014-04-30	53	6	6	Project Manager
7a 7b 7c	Visit, Visit, E-mail, Visit	N/A	2014-04-14, 2014-04-25, 2014-05-05, 2014-05-16	54	34	7	Director of administration
8	Telephone	37:11 min	2014-05-05	67	22	5	System administrator/ Project leader
9	Telephone	31:20 min	2014-05-05	64	35	10	Responsible for central maintenance

Table 2.2 Interviews

Qualitative interviews were chosen instead of quantitative surveys because the purpose was to get a profound comprehension regarding a certain phenomenon, technology debt (Patel and Davidson, 2003). The interviews involved quantitative elements as well. These elements helped the visualization of the valued technology debt and to pinpoint the differences between the investment options (Patel and Davidson, 2003). Respondents valued the future level of technology debt caused by the two investment options on a Likert-scale, ranging from 1-7. These values were explained during the interviews, as seen in the questionnaire. Values are presented in radar charts as suggested by several researchers (Kobayashi et al., 1994; Kaczynski, Wood, and Harding, 2008). Six interviews were conducted at the company's head office. These were recorded, transcribed and sent back to all the respondents for validation. The location had no disturbances and assured the respondents of their well-being and safety, as suggested by Trost (2005). Trost (2005) also suggest that when there are two or more interviewers there is a possibility that the respondents will feel intimidated. This concern was taken into consideration during the interviews. Two telephone interviews were carried out and recorded, but could not be transcribed due to technical issues relating to the quality, owing to background noise. The last interview was done via email, where the respondent filled out the questionnaire. This was deemed qualitative as the respondent had received a thorough explanation of the questions at a previous informal meeting. One of the recordings from the interviews at the head office was lost due to technical issues. The interviews were recorded to increase focus on the questions and the

answers instead of putting too much energy into taking notes, as suggested by Trost (2005). All the respondents were informed that all the information they had provided was treated confidentially. Only the interviewers and their supervisor have access to the transcripts, which have been anonymized, in accordance with Trost (2005). The results from the interview study are presented in 4.2. and its analysis is presented in 5.2.

2.2.3. Study 3 (Evaluation-study)

Several researchers proclaim the value of properly evaluating a theory (Nunamaker, Chen, and Purdin, 1990-91; Swenson, 1999; Peffers et al., 2008; Eisenhardt, 1989; Hevner et al., 2004; Vaishnavi and Kuechler, 2004). The evaluation can take many forms as the following quote exemplifies: "*...evaluation could take many forms. It could include such items as a comparison of the artifact's functionality with the solution objectives from activity two above, objective quantitative performance measures, such as budgets or items produced, the results of satisfaction surveys, client feedback, or simulations. It could include quantifiable measures of system performance, such as response time or availability.*" (Peffers, 2008). To evaluate the framework that is developed within this thesis, an evaluation of the results from the case study has been made with the CFO/CIO of Company AB. This evaluation will support the validity and relevance of the thesis (Bryman and Bell, 2007). Drawing from these previous examples of criteria, for theory evaluation, the following three were covered by several researchers; parsimony, operationality, and empirical support. These are explained below.

2.2.3.1. Parsimony

Swenson (1999) states that one of the intentions of a theory is to explain reality by simplification. A theory thus requires assumptions and explanations to be provided within generally accepted parameters. If this is not the case, and assumptions are unconventional, the theory is deemed not parsimonious (Swenson, 1999). The danger of a case study is the potential to miss certain relationships visible in for example a multicase study, according to Eisenhardt (1989). It is important for the theory and its assumptions to be generalized and defined so that the result can be replicable (Eisenhardt, 1989).

2.2.3.2. Operationality

In order for a theory to be replicated and properly tested, its method must be constructed in a way that is usable by other researchers (Gregor, 2006). The fitness of the research process needs to be evaluated, and thus give support to the theory tested (Corbin and Strauss, 1990). Key terminology and concepts should be operationally defined for any good theory as stated by Swenson (1999). Swenson (1999) further stress the importance of demonstrating or measuring the terms and concepts through their definitions. Operationality also enables different researchers to conduct similar studies and obtain similar results (Swenson, 1999)

2.2.3.3. Empirical support

When a theory is tested Swenson (1999) states that it is important that it provides evidence of its applicability. Experiments should be conducted to illuminate the accuracy and utility of the theory as well as evidence, not just logic, to support the assertions of the theory (Swenson, 1999; Eisenhardt and Graebner, 2007). The empirical grounding of research findings always needs to be properly judged and evaluated (Corbin and Strauss, 1990; Eisenhardt and Graebner, 2007).

2.2.3.4. Evaluation with the CFO/CIO

The evaluation contained a presentation of the obtained results from the interviews. During the evaluation, an analysis was conducted. This analysis tried to weigh the different categories according to their relevance to Company AB. Afterwards there was a discussion where the CFO/CIO gave feedback and answered questions regarding the relevance of the findings in their decision-making process. The results from study 3 are presented in 4.3. and its analysis is presented in 5.3.

2.2.4. Data analysis

The discussion is where all the concepts stemming from previous research and our results are compared and weaved together to form a coherent understanding and ensure that the results are founded on research. It will be divided into three parts each representing one of the operational questions presented in 1.2.

2.2.5. Conclusions

The conclusions will culminate in an answer to the RQ and give the implications for both research and practice found through this thesis. Suggestions for future research are given based on interesting angles found during this research process.

2.3. Consideration of research ethics

Throughout this thesis research ethics provided by Vetenskapsrådet have been take into consideration. There are four specific principles that are explained further below.

2.3.1. The requirement of information

"*The researcher shall inform the information provider and the survey participant about their specific role within the project and the terms of their participation. They shall be informed that they have the right to disrupt their participation at any time and that their participation is voluntary. The given information shall cover all the features of the current survey that can possibly affect their willingness to participate (Free translation)*" (Vetenskapsrådet, 2002, p. 7).

All of the interviewees were informed before the interview about their contribution to the project, how their answers would be used and what the terms were for their participation. They were also informed that they had the right to disrupt their participation at any given time.

2.3.2. The requirement of consent

"*The consent of the information provider and the survey participant needs to be provided to the researcher. In the case of for example juvenile participants the consent needs to be provided by the parent(s)/caregiver(s). The participants of a survey shall have the right to independently determine under what terms they will participate, and for how long. They shall be able to disrupt their participation without incurring any negative consequences. The participants shall not be pushed or influenced by external forces when they make their decision to participate or disrupt their participation. There should not be any dependency relation between the researcher and the participations of the survey/the respondent (Free translation)*" (Vetenskapsrådet, 2002, pp. 9-10).

The thesis has been carried out with consent from all participants. None of the participants chose to disrupt their participation.

2.3.3. The requirement of confidentiality

"*The staff within a research project should sign a contract regarding the confidentiality about the personal information that is used in the project. All information about identifiable individuals shall be noted, stored and reported in such a way that specific participants cannot be identified by outsiders. This specifically applies to personal information that can be ethically sensitive. This means that it should be practically impossible for outsiders to obtain personal information about the respondents (Free translation)*" (Vetenskapsrådet, 2002, p. 12).

All individuals have been anonymized within the thesis, and any personal information is kept secure. Only the interviewers and their supervisor have access to personal information. All files containing personal information have been coded or destroyed after the completion of the project. Through this process the integrity of the participants was ensured, and it is practically impossible for outsiders to obtain harmful information. All participants are aware of who else participated in the project, as they work within the same organization, yet they have no practical way of knowing specific answers provided by a specific respondent.

2.3.4. The requirement of usage

"*The personal information that is gathered for the research project is not allowed to be used for commercial purposes or other non-academic reasons. Personal information submitted for research, cannot be used to make decisions or take action, institutionalize or similar consequences, that directly affects the individual, without their consent (Free translation)*" (Vetenskapsrådet, 2002, p. 14).

The information about the participants in the case study has only been used for the purpose of this thesis. The information was not used to directly affect any of the participants.

2.4. Trustworthiness and authenticity

Reliability and validity have long been two important criteria when conducting research. This paper will be evaluated by alternatives to these two terms. It is necessary to specify the terms by which a paper is evaluated, according to Bryman and Bell (2007). Bryman and Bell (2007) present two new main criteria to measure the reliability and validity of a study: trustworthiness and authenticity. Trustworthiness is split into four categories: credibility, transferability, dependability and confirmability. Authenticity is measured by five different variables: fairness, ontological authenticity, educative authenticity, catalytic authenticity and tactical authenticity (Bryman and Bell, 2007).

- Throughout the research, respondent validation has been used to receive high credibility on the empiric data that has been found. The sources in the literature review have been deeply investigated to check their reliability, for further explanation, see below in 2.5 (Bryman and Bell, 2007).

- The transferability of the findings in this study is high due to the high validity achieved in 2.2.1.1.1. The framework presented could be applicable on other companies that are evaluating IT-investment options, according to the evaluation-study. Because of this, the thesis satisfies the transferability criteria (Bryman and Bell, 2007).

- By showing all of the phases during the research process, transparency has been accumulated. This transparency aims to assist the reader when measuring the dependability of this thesis. Through this, dependability has been added (Bryman and Bell, 2007).

- Achieving complete objectivity in research is impossible. By not adding personal values when writing the thesis and ensuring the correctness of the given results through validation and an evaluation, objectivity was satisfied. By taking the above into consideration, confirmability has been added to the thesis (Bryman and Bell, 2007). The objectivity of the sources has been evaluated, see 2.5.

To aid the authenticity throughout the research progress four principles developed by “Vetenskapsrådet” have been taken into consideration. This gives the thesis authenticity. Through evaluating the four categories of trustworthiness above, high reliability and validity have been achieved (Bryman and Bell, 2007).

2.5. Source criticism

A criticizing standpoint has been used constantly to confirm the reliability of the used sources. Four primary questions, provided by Patel and Davidson (2003), have helped in this aspect:

- *When and where was the document created?*
- *Why has the document been created, and what was the author's purpose(s) with the document?*
- *Under what circumstances was the document produced?*
- *Who is the author of the document and what knowledge does (s)he have within the related field?*

Since the research field surrounding IT-investments constantly evolves, due to new technological advances, the novelty of the used sources was deemed relevant. This was also relevant as the amount of research concerning technology debt is scarce. Throughout the literature review the publication where articles were published was taken into consideration. This helped evaluate the authenticity and objectivity of the document. Through the evaluation of the author a measure of the reliability of the document was developed.

2.6. Limitations

After the conduction of the interviews a mistake was identified. In the typology presented in 4.1., the category “Working environment” is linked to users, whereas it should be linked to IT-staff. This did not cause any problems as the category was evaluated from the viewpoint that it concerned users. A limitation is that the categories are equally weighted. This aspect was not considered in this thesis and therefore not further explored. Finally, as mentioned previously, the real-option approach will not measure the investment options in monetary terms.

3. Previous research

Here relevant theories stemming from previous research will be presented in order to build an understanding of the terminology and contributing concepts. This will later be used as a tool for analyzing the empirical findings and contextualize the results of the case study.

3.1. IT-infrastructure

There are various definitions of IT-infrastructure that contribute to the overall definition. Nyrhinen (2006) draws together many research streams in order to create a holistic model for IT-infrastructure. She finds various theories that assist by identifying four purposes of IT-infrastructure:

1. *"forms a (technical and human) basis for business and business applications.*
2. *holds, routes, assembles and shares information, satisfying business and management needs for reducing costs and increasing efficiency.*
3. *enables the planning and modifications of business processes, supports the emergence of new organizational forms, improves connectivity among interest groups and helps globalization.*
4. *fosters the attainment of sustainable competitive advantage as a core competence of the firm, and, as a flexible platform, enables rapid new implementation of innovations and cost effective modifications of existing applications."* (Nyrhinen, 2006, p. 4).

Following from these purposes she concludes that *"...IT-infrastructure plays an important role in the operations of every firm*"(Nyrhinen, 2006, p. 4). Resting on previous research some sources are worth distinguishing as they were also referenced elsewhere; contributing to a general understanding of IT-infrastructure as a concept. IT-infrastructure consists of shared IT capabilities that together create a foundation for the entire business (McKay and Brockway, 1989). IT-infrastructure is the institutionalized IT practice of an organization and its complete information capacity. This capacity is then meant to be shared throughout the organization (Davenport and Linder, 1994). IT-infrastructure is the shared IT resources that are combined as a foundation for business applications (Duncan, 1995). Based on this research the interpretation of IT-infrastructure in this thesis encompasses the combined IT-capabilities and shared IT practice of a company (Nyrhinen, 2006; Byrd and Turner, 2001). With competent IT-staff and a flexible IT-infrastructure a comparative advantage towards competitors can be applied (Bharadwaj, 2000).

3.2. IT-governance

IT-governance has been defined as: "*the decision rights and accountability framework for encouraging desirable behaviours in the use of IT*" (Weill and Ross, 2004a, p. 4). Another definition available is: *"...IT governance, in turn, is much broader* [contrasted to IT management] *and concentrates on performing and transforming IT to meet present and future*

demands of the business and the business' customers." (van Grembergen and De Haes, 2005, p. 1) However, as found by Simonsson and Johnson (2005), there is no unified definition of IT-governance except that it is connected to decision-making. This thesis uses the definition suggested by Weill and Ross (2004a) and further affirmed as relevant by Brown and Grant (2005). Weill and Ross (2004a) found that the focus of IT-governance is to ensure that a corporation achieves their goals, through the assistance of IT. IT-governance is not to be isolated from governance of other asset processes as it represents a link to other key enterprise assets (i.e. financial, human, physical, and relationships) (Weill and Ross, 2004a; van Grembergen, 2000; De Haes and van Grembergen 2004; Sethibe, Campbell, and McDonald, 2007). Both Weill and Ross (2004a) and Simonsson and Johnson (2005) emphasize the different levels of decision-makers and their impact on how their decisions align with overarching strategy and goals. As stated by Weill and Ross (2004a) all corporations engage in IT decision-making yet their definitions of accountability and the rigidity of their decision-making processes are not the same. Efficient IT-governance requires the following concerns to be addressed, according to (Weill and Ross, 2004b; Ko and Fink, 2010):

1. What decisions must be made to ensure effective usage and management of IT?
2. Who should make these decisions?
3. How is the decision process formalized?

Corporations with high growth in market capitalization typically have very high decentralization in their IT-governance and this result in maximum autonomy to individual business units and their managers (Weill and Woodham, 2002). Reinhard (2012) state that effective IT-governance helps ensure that IT adds value and contributes to profitability, which aligns with conclusions drawn by Marks (2010). IT enables distribution of decision-making abilities across organizational boundaries and allowing autonomous units to exert authority and control (Tiwana, Konsynski, and Venkatraman, 2013).

3.3. Technology constraints

Since computers and IT was introduced and industries started to use it as an important piece in their business strategies, there was an initial belief that firms would reap tremendous productivity benefits (Brynjolfsson, 1993). However, there is research that contests these beliefs and claims that technology has not generated the assumed results. This is referred to as the productivity-paradox (Brynjolfsson, 1993; Macdonald, Anderson, and Kimbel, 2000; Carr, 2003). This indicates that there might be some sort of constraining characteristics to technology. Previous research in this field has mainly focused on three different fields of technology constraints. These are: Network economics, Information infrastructure, and Institutional theory (Magnusson and Bygstad, 2014). Network economics encompasses path dependency and lock-ins. Path dependency explains that there is a strong influence caused by previous choices in for example systems and design of these systems. Through this influence a company might also experience

lock-ins where they become forced to make certain decisions due to the chosen path. The reason why companies are forced to stay on this path is because changing direction causes switching costs. Switching costs refers to costs related to implementing a new technology, and if these are too high a lock-in is in effect (Shapiro and Varian, 1999). Because investing in a certain IT-infrastructure usually includes adapting your current systems to whatever standards the new system requires (Shapiro and Varian, 1999). Information infrastructure is a wider concept than the previously interpreted IT-infrastructure and is defined as "*a shared, open, heterogeneous and evolving socio-technical system, consisting of a set of IT capabilities and their user, operation and design communities*" (Hanseth and Lyytinen, 2010). Institutional theory argues that individuals and their decisions are shaped, and also restrained, by shared systems, values and resources (DiMaggio and Powell, 1983). Companies working in such an environment will experience even more constraints (DiMaggio and Powell, 1983).

3.4. Theory of technology debt

In the field of software engineers there has been something called technical debt which refers to when programmers create a quick-fix, by programming, to a problem in order to enable them to reach deadlines on time and then go back and fix the problem properly (Cunningham, 1992). Based on this concept technology debt brings together the aforementioned three different fields regarding technology constraints and to this adds debt, a central theme in finance theory, similar to Allman (2012). Debt is defined as "*an obligation owned by debtor to creditor with the expected repayment with interest*." (Elliot and Elliot, 2002). Through the unification of these concepts, a definition of technology debt is stated as follows: *"Accumulated obligation owned by current CIO (debtor) to future CIO (creditor), where previous decisions limit prospective decisions"*(Magnusson and Bygstad, 2014). There are four assumptions underlying the proposed definition:

1. Debt is accumulated over time as a consequence of decisions (Merton, 1974).
2. Debt is associated with a cost of interest (Modigliani and Miller, 1958).
3. The cost of interest and the total amount of debt influences prospective decisions, through limiting the amount of funds available (Modigliani and Miller, 1963).
4. Debt is a necessary element of the capital structure of the firm (Jensen and Meckling, 1976).

It is important to remember that debt is not inherently negative, but rather incurred as a consequence to previous decisions (Merton, 1974). However, to this a definition of the required interest is added: *"Cost consisting of a decrease in maneuverability in future options"* (Magnusson and Bygstad, 2014). With the ambition of studying technology debt a process is described. In this process an investment decision leads to either increased debt by taking a "loan", meaning that the decision leads to future path dependency and/or lock-ins, or "amortization", meaning it was made to decrease the already accrued technology debt. Resulting

from the proposed process is the current technology debt, caused by previous investments (Magnusson and Bygstad, 2014).

3.5. Real-option Theory

Utilizing real-option theory to evaluate and facilitate decision-making regarding investments has been suggested by several researchers (Dixit and Pindyck, 1994; Kogut and Kulatilaka, 1994; Kulatilaka and Marcus, 1992; Balasubramanian, Kulatilaka, and Storck, 2000; Ullrich, 2013). As uncertainty and irreversibility are of relevance to the decision maker it is appropriate to view the investments as real options (Amram and Kulatilaka, 1998; Dixit and Pindyck, 1994; Fichman, 2004; Trigeorgis, 1993). According to Fichman (2004) there are two main considerations when adopting changes to the IT infrastructure: the uncertain benefits of the investment, and the irreversibility of the associated costs. Associated costs refer back to the previously defined concept of switching costs (Fichman, 2004; Shapiro and Varian, 1999). Uncertainty is caused by the nature of IT itself and the strategic path dependency on a firms IT trajectory (Fichman, 2004; Page, 2006). When making investment decisions, using a real-option approach, managers are expected to take into account the value captured by the (investment-) options (Fichman, 2004). The valuation of investment options is slightly different, compared to financial options, due to the underlying asset (IT-investment) being considered non-tradable, as pointed out by Kumar (2002). Kumar (2002) explains that this can be solved by using alternative valuation models when deemed appropriate. Amram and Kulatilaka (1998) clearly state that real-options are the only way to properly evaluate investments with this magnitude of uncertainty. One established approach when choosing between options is to construct a (binomial) decision tree with valuations of each possible option (Brandao, Dyer, and Hahn, 2005).

4. Results

Here the results from the thesis' three parts will be presented. First, study 1 provides substance to the theory map in order to build a foundation for the questionnaire. This will supply the second result with a theoretical essence. Second, the results from the conducted interviews are twofold; a compilation of thoughts and responses from the interviewees, and a visualization of the company's technology debt as measured during the interviews. Finally, the results from the evaluation are presented.

4.1. Results from study 1

As technology debt is identified it can further be categorized into nine categories, according to the typology below in figure 4.1, hereafter referred to as the theory map;

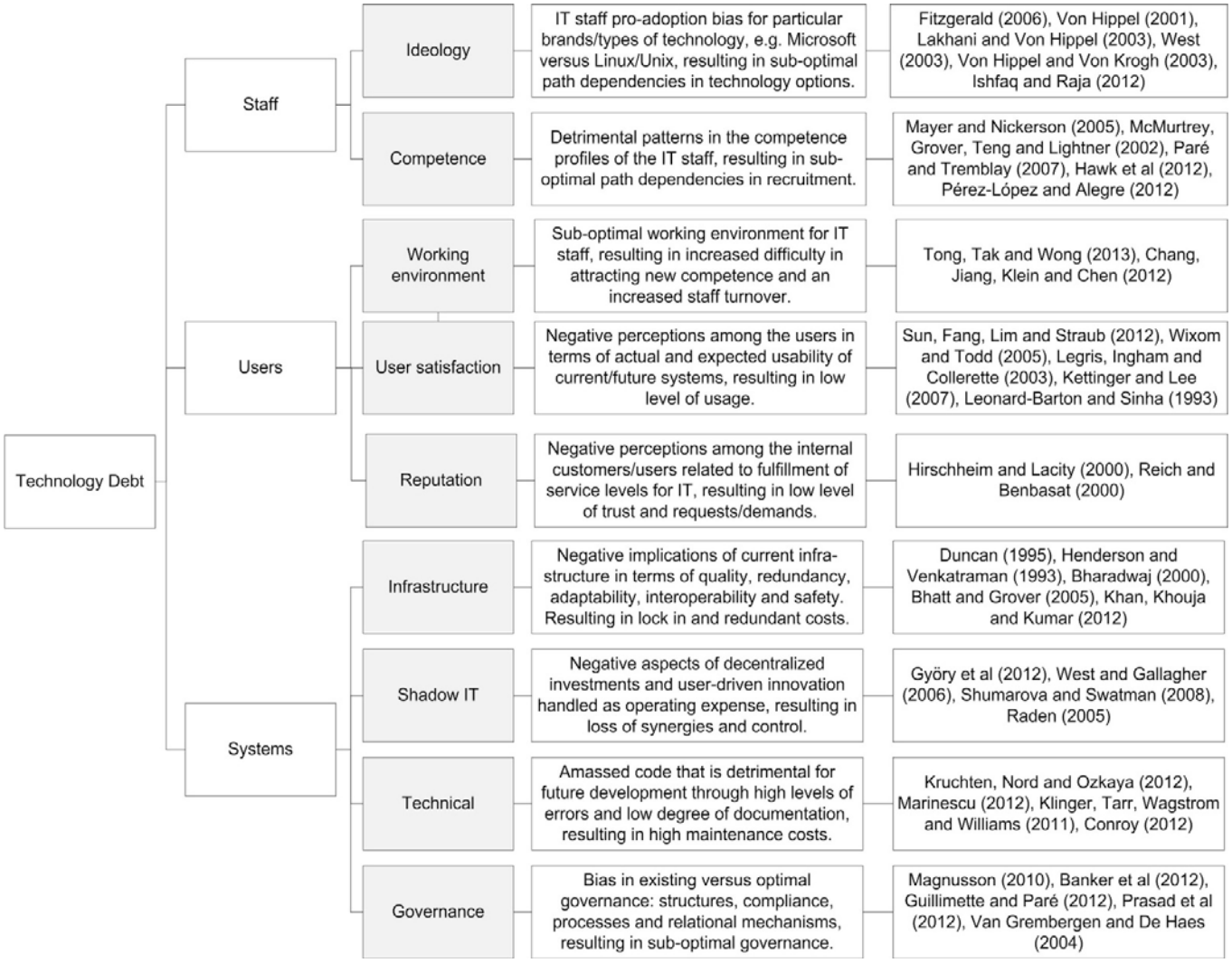

Figure 4.1 Typology of Technology Debt (Magnusson and Bygstad, 2014)

This typology will be briefly explained in separate segments below. Note that the tenth category "autonomy" is not in the theory map since this is a new aspect added to the original theory.

4.1.1. Staff

This subcategory focuses on the IT-staff and the technology debt associated with them.

4.1.1.1. Ideology

Staff in charge of implementing IT-investments might associate themselves with different ideological patterns in IT. A classic example of this is Microsoft versus Linux, one producing proprietary software and the other being open source software. Employees who belong to the open source community tend to promote its usage. Sometimes this also leads to an ideological rather than a decision based on business rationale (Ven and Verelst, 2008). There are examples of software that is being actively developed and supported by its users, for example Apache (Lakhani and Von Hippel, 2003). There is considerable competition and different strategies between IT-firms relating to ideology. Richard Stallman, a former programmer at Massachusetts Institute of Technology founded the Free Software Foundation in order to promote free software. A further definition of free and open source software is not of relevance to this thesis, for a more in-depth exploration; see for example Rossi (2004). For example, IBM supported open source as a means to undermine their competition from other software providers such as Microsoft and Sun Microsystems. They were also able to provide complementary support to users of these open source software as a business strategy (Von Hippel and Von Krogh, 2003; Fitzgerald, 2006). Proprietary software vendors create agency costs as they do not have the same incentives to improve their products as the local staff. Staff might thus seek out alternatives that allow them a system where they are in control (Von Hippel, 2001; Fitzgerald, 2006). Choosing either vendor causes the firm to become locked-in to that vendor for a longer period of time as illustrated by the following quote "*That makes it a lot more competitive and lowers the price to the user. That's not exactly what all the technology companies want to do. They want to get you locked in*" (Taylor, 1996; West, 2003). The purpose of this category is thus to identify if a preference exists among the IT-staff of the company. These kinds of preferences might lead to suboptimal path-dependencies in technology options (Magnusson and Bygstad, 2014).

4.1.1.2. Competence

When companies recruit staff to their high technology teams/projects there are many specific competences they actively look for and wish to attract. Employees who share values with their employers tend to stay with that organization for a longer period of time (Paré and Tremblay, 2007) These values then affect the employees choices and other events at the workplace (McMurtrey et al., 2002). Thus companies spend vast resources ensuring their employees obtain skills required by the organization. Likewise employees tend to stay if they perceive a potential cost of leaving. Knowledge regarding these patterns pervades their human resources-department (Paré and Tremblay, 2007). Management of IT knowledge and competence has direct effect on firms' market performance and thus it is of outmost importance for firms to manage the skillset of their employees (Pérez-López and Alegre, 2012). Agency theory supports the theory that firms benefit from keeping their in-house employees compared to outsourcing (Mayer and

Nickerson, 2005). There is a strong collaboration between organizations and universities in their vicinity enabling tight symmetry between course curriculum and skills desired (Hawk et al., 2012). These patterns in competence and similarities in in values can lead to suboptimal path-dependencies when firms recruit (Magnusson and Bygstad, 2014).

4.1.2. Users

This subcategory focuses on the users of the IT-system and the technology debt associated with them.

4.1.2.1. Working environment

Organizations share values, norms, and practices with their employees. How strongly these elements are shared is important to the overall performance of the organization (De Long and Fahey, 2000; Tong, Tak, and Wong, 2013) Identifying with a certain group and professional discipline is equally important in maintaining a social identity, according to Chang (2010). Membership into the IT-professionals community requires having the right competencies, possessing relevant knowledge, and working in a group where your skill is recognized (Chang, 2010; Chang et al., 2011). Turnover among IT professionals continues to be substantial (Adams et al., 2006). Various factors and conditions contribute to the high turnover rate, according to Joseph et al. (2007). Joseph et al. (2007) explain that employees' sense of emotional environment, autonomy, and overall demands increases their propensity to switch jobs. General modifications to the working environment is the standard remedy, however this does not take into consideration the individual needs of the IT professionals (Joseph et al., 2007). Job satisfaction is one of the most important factors underlying employees' turnover intentions (Wheeler et al., 2007; Chang et al., 2012). IT-investments influence the working environment and thus affect job satisfaction among IT-professionals. This causes increased difficulty in attracting new staff while also increasing staff turnover (Magnusson and Bygstad, 2014).

4.1.2.2. User satisfaction

It is crucial for management to determine how effective an organization is, as stated by Kettinger and Lee (1994). A perspective while measuring effectiveness needs to be user satisfaction (Kettinger and Lee, 1994). For an IT-system to be contributing to firm performance and thus increasing the business value, it needs to be used in alignment with the overall strategies of the organization (Davis, 1989). Therefore, ease of use inside the system is vital (Davis, 1989; Venkatesh, 2000; Legris, Ingham, and Collerette, 2003; Calisir and Calisir, 2004). If the user interface is complex and not easy to use, it will result in low level of trust and usage among the users (Magnusson and Bygstad, 2014).

4.1.2.3. Reputation

In the process of implementing a new IT-system, it is important to have the perception among the users in mind (Moore and Benbasat, 1991). The social construction of reality proclaims that in addition to studying IT-infrastructure or the IT-organization, researchers must investigate the contents of the user's mind (Berger and Luckmann, 1967). How their beliefs, attitudes, and understanding towards the changing of the present infrastructure and organization are influenced by reputation, created by previous successful implementations (Reich and Benbasat, 2000). This category will measure how this pre-perception will force a lock-in on a future decision-maker (Magnusson and Bygstad, 2014).

4.1.3. Systems

This subcategory focuses on the overall IT-system of the organization and the technology debt associated with it.

4.1.3.1. Infrastructure

Having a flexible IT-infrastructure is something companies value significantly (Bharadwaj, 2000). If you do not have a flexible IT-infrastructure you cannot handle the quantity of unplanned system requirements faced by the IT-infrastructure (Duncan, 1995). IT-infrastructure encompasses the combined IT-capabilities and shared IT practice of a company (Nyrhinen, 2006; Byrd and Turner, 2001). Another possible outcome of not having a flexible IT-infrastructure is the inability to act on certain business opportunities (Duncan, 1995). A company can be locked in within the system infrastructure and this causes consequential costs (Magnusson and Bygstad, 2014).

4.1.3.2. Shadow IT

Whenever the IT-system cannot provide all the services that the company requires, something referred to as "Shadow IT" is generally developed. If there is a service that cannot be found within the current IT-system, user-driven innovations will try to create solutions to this lack of appropriate systems (Raden, 2005). An example is when users make their own excel spreadsheet to fill the gap that their current IT-system cannot help them with (Raden, 2005). The use of this spreadsheet instead of centralized spreadsheets exposes the company to risks, in terms of security and/or quality, attributable to their solution (György et al., 2012). The amount of shadow IT will thus be an indication of the IT-systems lack of functionality and consequently technology debt (Magnusson and Bygstad, 2014).

4.1.3.3. Technical

Companies sometimes take a short-term decision when it comes to writing code inside an IT-system. This will lead to the phenomenon called "technical debt" (Cunningham, 1992; Kruchten, Nord, and Ozkaya, 2012). It is important to document the background to written code within an

IT-system. If this is not done properly, it will be problematic to fix this code later (Klinger, 2011). When implementing a new IT-system a company is given an opportunity to carry out a proper implementation, removing faulty code (Parnas, 1994). Technical debt affects future development of the IT-system through poorly written code and lack of documentation which leads to an increased level of technical debt (Magnusson and Bygstad, 2014).

4.1.3.4. Governance

Since IT-governance in companies has changed radically the last 50 years, the organization and the top management have been forced to change as well (Guillemette and Paré, 2012). IT-systems have had a large impact on how companies are governed in the modern world (Guillemette and Paré, 2012). Due to this, companies today spend vast amounts of money trying to find the ideal strategy for IT-governance. The ideal IT-governance strategy involves IT that sustains and extends the company's objectives and strategies (Prasad, Green, and Heales, 2012). If you cannot find your optimal IT-governance strategy, you will have sub-optimal governance that will have an effect on your organization and its management (Magnusson and Bygstad, 2014).

4.1.4. Autonomy

The category, autonomy, was added in order to measure how a subsidiary would be affected by an enforced IT-investment from a parent company (Interview 7b). The parent company often wants control within the corporate group, whereas the subsidiary prefers autonomy (Birkinshaw et al., 2001). This can get problematic since the subsidiary can be forced to implement an IT-investment which cripples the subsidiary’s ability to act autonomously (Simoes, Biscaya, and Nevado, 2000). Since some IT-investments will weaken/strengthen the ability for a subsidiary to act autonomous in the long term, this category is relevant when measuring the technology debt for a subsidiary (Interview 7b).

4.2. Results from study 2

Here the results from the conducted interviews will be presented in two parts. First, the comments concerning Investment Option 1 (IO1) are categorized by the typology described above. Second, Investment Option 2 (IO2) is categorized in the same order. These two parts are where the interviewees gave general responses arguing in favor of their measurement of technology debt caused by either investment option. These measures are visualized in radar charts Summarized interviews and tables are available in Appendix A and B.

4.2.1. Results from the interviews: Investment option 1 (IO1)

To review, IO1 is a potential upgraded version of a part in the current IT-infrastructure. IO1 is the current ERP-system used by Company AB. The system has been used for about 15 years by the company. Below are two charts visualizing how the technology debt would change from the

present state if they were to implement IO1. The present state shows the current technology debt, where each category is given the value four.

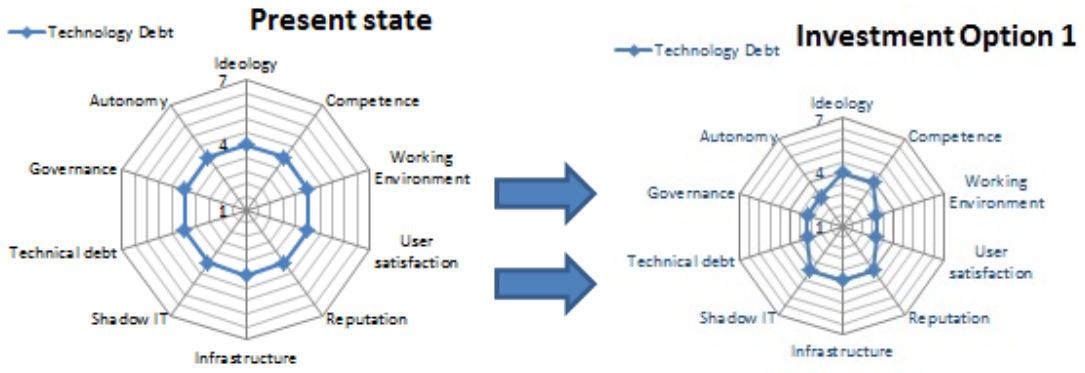

Figure 4.2 Technology debt incurred by IO1

The following section will contain statements underlying the given values from the interviewees. All the questionnaires and charts are available in Appendix A and B.

Ideology: Seven out of nine interviewees thought that there would be no change in ideology compared to the current state. There was also a comment about how an implementation of IO1 would give a future CIO a smoother transition to his new position. Resulting **median 4**, i.e. no change in technology debt within this category.

Competence: Five interviewees believed that there would be no change in the concentration of competence compared to the present. Three of the interviewees thought that there would be a slight decrease in the concentration of competence among the IT-staff. Resulting **median 4**, i.e. no change in technology debt within this category.

Working environment: Six interviewees described that an implementation of IO1 would give IT-users an increased possibility to influence the development of the IT-system. One interviewee said ‘’*at least they will <u>believe</u> that they have an impact on development, even if that might not be the case (free translation)” (Interviewee 6).* Another interviewee said that an implementation of IO1, being an upgrade of the currently outdated system, would give the users a rare opportunity to improve the working environment. Resulting **median 3**, i.e. an implementation of IO1 would slightly amortize the technology debt within this category.

User satisfaction: Five interviewees thought that an implementation of IO1 would give the IT-users a new and fresh user-interface. This results in an increased user satisfaction. However, in the short-term there would be a small threshold as it is a new interface. Resulting **median 3**, i.e. an implementation of IO1 would slightly amortize the technology debt within this category.

Reputation: Four interviewees believed that IO1's reputation would have no effect on the willingness to use the IT-system. However, there were four other respondents who claimed that there was a reputation surrounding IO1 that would increase the willingness to use the IT-system. Resulting **median 4**, i.e. no change in technology debt within this category.

Infrastructure: Four interviewees thought that the systems infrastructure and its flexibility would not change compared with today. Two respondents had the belief that an implementation of IO1 would increase the flexibility of the infrastructure due to previously obtained knowledge. In contrast, three of the interviewees believed that there would be decreased flexibility. They thought insufficient knowledge would cause the development of interface/modules to require both money and time. Resulting **median 4**, i.e. no change in technology debt within this category.

Shadow IT: Four interviewees believed that the total amount of shadow IT within the company would not change compared with today. An equal amount thought that there would be a decrease in the amount of shadow IT since an implementation of IO1, supposedly, contains functions previously performed by shadow IT. Resulting **median 4**, i.e. no change in technology debt within this category.

Technical: All of the respondents believed that the amount of faulty code would either decrease or stay unchanged. Seven of the interviewees thought that an implementation of IO1 would decrease the amount of flawed code. Replacing the old system with an upgraded version would remove previous emergency solutions that caused problems when developing new interfaces/modules. Resulting **median 3**, i.e. an implementation of IO1 would slightly amortize the technology debt within this category.

Governance: Since the new functions included in an implementation of IO1, six of the interviewees claimed that Company AB would have an increased ability to govern with the assistance of IT. *"Since our current system is outdated, an upgraded version would give us new functions increasing our ability to govern using IT (free translation)"* (Interviewee 4). Three interviewees assessed that there would be no change in using IT to govern the company. Resulting **median 3**, i.e. an implementation of IO1 would slightly amortize the technology debt within this category.

Autonomy: With an implementation of IO1, Company AB would not be as locked-in by the IT-systems, according to five of the respondents. Interviewee 7 states that Company AB currently share some functions of the current IT-system with another company within the corporate group. (S)he also claims that the implementation of IO1 would liberate them from this dependency, resulting in a more autonomous business unit. Resulting **median 3,** i.e. an implementation of IO1 would slightly amortize the technology debt within this category.

Summary IO1: Adding the ten medians together gives a total technology debt of 35, i.e. an implementation of IO1 would amortize the technology debt from the current state of 40 units to 35 units.

4.2.2. Results from the interviews: Investment option 2 (IO2)

To review, IO2 is an ERP-system that Company AB has been implementing for the past decade. IO2 is a specific template developed by Company AB's parent company. Below are two charts visualizing how the technology debt would change from the present state if they were to choose IO2. The present state shows the current technology debt, where each category is given the value four.

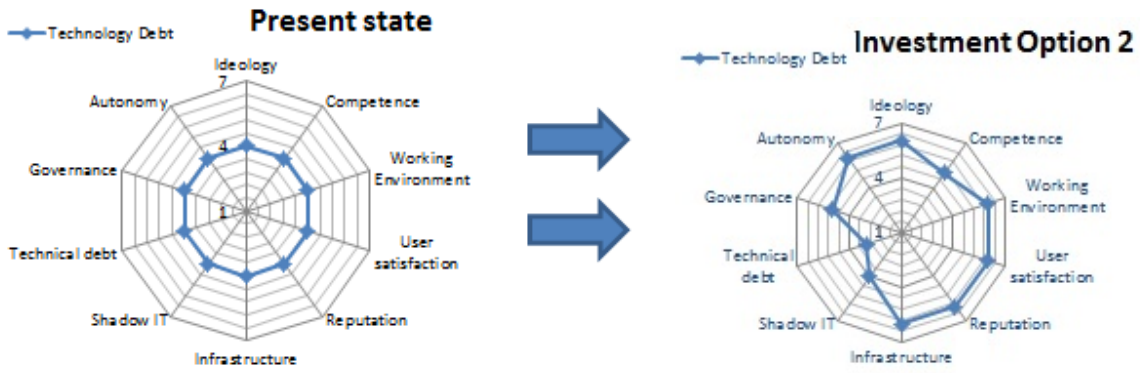

Figure 4.3 Technology debt incurred by IO2

The following section will contain statements underlying the given values from the interviewees. All the questionnaires and charts are available in Appendix A and B.

Ideology: With an implementation of IO2, a future CIO would have to make decisions regarding IT-investments based on ideology instead of a rational business choice. This was the belief among seven of the respondents. One of the interviewees claimed that IO2 would become the ex post standard among the IT-staff, severely affecting ideology. Resulting **median 6,** i.e. an implementation of IO2 would increase the technology debt within this category.

Competence: Five of the respondents believed that with the implementation of IO2, an increased concentration of competence was deemed likely. However, since IO2 is a widely used IT-system, two of the respondents thought that it would be easier to recruit people with relevant skills than at the present state. There was also a belief among two of the respondents that the concentration of competence among IT-staff would remain unchanged. Resulting **median 5,** i.e. an implementation of IO2 would slightly increase the technology debt within this category.

Working environment: A strong majority, eight interviewees, claimed that the working environment would be worse compared with the present state. This negative impact was traced to the lack of influence among the IT-users would have on the implementation of IO2. There was

an outlier who believed the opposite, that IT-users would have a greater influence on the development than of today. Resulting **median 6,** i.e. an implementation of IO2 would increase the technology debt within this category.

User satisfaction: A strong majority, eight interviewees, believed that the user satisfaction among the IT-users would decrease. Primary arguments were the fact that the new system was standardized and complex. Therefore, as one interviewee states, it is not an optimal solution for the IT-users. Contrary to the others; one interviewee claimed that a new system, regardless of which, would increase user satisfaction as it is a new system. Resulting **median 6,** i.e. an implementation of IO2 would increase the technology debt within this category.

Reputation: "*...(IO2) has an infamous name in Sweden.…..run the other way (free translation)*" (Interview 2). Due to a bad implementation of IO2 at another company in the corporate group, eight of the respondents were not eager to implement IO2 and believed that it would decrease the willingness of the IT-users to work within the system. Resulting **median 6,** i.e. an implementation of IO2 would increase the technology debt within this category.

Infrastructure: Seven interviewees believe that there would be increased costs to develop new internal interfaces/modules, due to the complexity of adjusting IO2 to Company AB's specific needs. IO2 will not cooperate with the other systems as effectively. Two respondents said that there would be no change compared with the infrastructure of today. Resulting **median 6,** i.e. an implementation of IO2 would increase the technology debt within this category.

Shadow IT: The respondents had a wide array of opinions on the effect on the amount of Shadow IT. Four interviewees believed that the amount of Shadow IT would increase as IT-user will prefer Shadow IT over the complex IO2. Interviewee 3 states that the report generator is considered suboptimal within IO2, increasing IT-users reliance on Shadow IT. Among three respondents there was a viewpoint that an implementation of IO2 would not have an effect on the amount of Shadow IT within Company AB. Finally, two interviewees said that IO2 would include new features and thus reducing the amount of Shadow IT. Resulting **median 4**, i.e. no change in technology debt within this category.

Technical: All of the respondents believed that the amount of flawed code would either decrease or stay unchanged. Seven of the interviewees claimed that an implementation of IO2 would decrease the amount of suboptimal code. Replacing the old system with an entirely new system would remove previous emergency solutions that caused problems when developing new interfaces/modules. Resulting **median 3**, i.e. an implementation of IO2 would slightly amortize the technology debt within this category.

Governance: Five of the interviewees assessed that Company AB would suffer from less ability to govern using IT in the case of an IO2 implementation. Contrary to this, two respondents claimed that IO2 would give Company AB an increased ability to govern with the assistance of IT. *"Since our current system is outdated, an upgraded version would give us new functions increasing our ability to govern using IT (free translation)"* (Interview 4). Two interviewees thought that there would be no change in using IT to govern the company. Resulting **median 5**, i.e. an implementation of IO2 would slightly increase the technology debt within this category.

Autonomy: A strong majority, eight interviewees, gave clear implications that an implementation of IO2 would severely decrease Company AB's ability to act autonomously. Increased integration into the corporate group will cause a decrease of self-dependence. Interviewee 6 claims that the enforced template will cause serious lock-in effects on Company AB's ability to perform as an autonomous business unit. Resulting **median 6,** i.e. an implementation of IO2 would increase the technology debt within this category.

Summary IO2: Adding the ten medians gives a total technology debt of 53, i.e. an implementation of IO2 would increase the technology debt from the current state of 40 units to 53 units.

4.3. Results from study 3

The results will be evaluated from three criteria; parsimony, operationality, and empirical support. By fulfilling these criteria, validity and relevance are added to the thesis. Below the results from the evaluation with Company AB's CFO/CIO are presented.

4.3.1. Parsimony

During the evaluation with the CFO/CIO, (s)he claimed that due to the specification of the framework, the results from the case study can act as a complement for Company AB (Interview 7c). The tapered view-point assisted in highlighting the future consequences that were examined (Interview 7c).

4.3.2. Operationality

The CFO/CIO claimed that the theory of technology debt could be used to evaluate future IT-investments (Interview 7c). (S)he also claimed that the framework could be operationalized in practice. The results from the case study can act as a complement to the decision-maker when evaluating the two alternative future IT-investments, according to the CFO/CIO.

4.3.3. Empirical support

The case study involved interviews with interviewees possessing a wide array of experience and competence. Since the case study involved nine unique respondents, empirical support of the results was achieved according to the evaluator (Interview 7c).

5. Discussion

The discussion is divided into three segments where each result is discussed. The results are weaved together with previous research. Stemming from these discussions, answers to the three questions that were posed as an operationalization of the research question are provided.

5.1. Discussion, study 1

1. How can technology debt be applied to future IT-investment options?

Current and future CIOs are path-dependent and required to live with the consequences of past CIOs decisions (Arthur, 1994; Kim and Sanders, 2002; List, 2004). This is exemplified by the case of Bell Atlantic and AT&T. Bell Atlantic suffered from an installation of AT&T's products that they could not maintain without support of AT&T. Bellman Atlantic were thus locked-in due to the high switching-costs attached to ridding themselves of AT&T (Shapiro and Varian, 1999; Farrel and Klemperer, 2005). A previous case study, conducted by Magnusson and Bygstad (2014), investigated how the present installed base is dependent on decisions made in the past, while this thesis focused on how the currently installed base will be affected by future IT-investments.

Results from the theory exploration gave various contributions describing each category in the typology in-depth and how to examine *future* IT-investments based on the defined categories. Adjustments to each category resulted in a questionnaire that compared the current state of Company AB's technology debt with two alternatives, IO1 and IO2.

First, IT-staff will be affected by an IT-investment in various ways. Changes to the IT-staffs ideology is similar to how companies get locked-in to a certain vendor, perhaps in the future by a decision made today, and would thus be forced to make a decision based on ideology (West, 2003) instead of a rational business decision. Companies will give birth to an institutional logic carrying its and their employees' values forward (DiMaggio and Powell, 1983). Thus the values conveyed from the company to their employees will remain in the company and shape their shared values in collaboration (Paré and Tremblay, 2007), and lead to future path-dependency (Magnusson and Bygstad, 2014).

Second, IT-investment will also affect IT-users in various ways. The working environment is important when considering IT-users turnover intentions (Wheeler et al., 2007; Chang et al., 2012). Turnover rates can be traced to users' ability to influence and modify the systems in which they are working (Joseph et al., 2007). IT-users highly value a simple user interface when working in the IT-system (Davis, 1989; Venkatesh, 2000; Legris, Ingham, Collerette, 2003; Calisir and Calisir, 2004). This is applicable on future IT-investments as well as previous IT-

investments. Another aspect is the IT-users perception of the investment resulting in altered willingness to work within the system (Reich and Benbasat, 2000).

Third, IT-systems will be affected by an IT-investment in various ways. Having a flexible and adaptable IT-infrastructure is vital for a firm to stay both competitive and in business (Bharadwaj, 2000). The company's information capacity, as presented by Davenport and Linder (1994), is altered whenever replacements are made to the IT-infrastructure, as supported by several interviewees. If an IT-investment includes more functions the amount of Shadow IT in the company should decrease and vice versa, a viewpoint shared by many interviewees. The amount of Shadow IT is directly linked to technology debt as it leads to lost synergies and less control (Magnusson and Bygstad, 2014). When implementing new systems there is a rare opportunity to get rid of old code, thus enabling the company to do a proper and new implementation without the disturbance of old and incomplete coding (Cunningham, 1992). The opportunity to remove old code was something the interviewees' recognized and valued. Companies today spend vast amount of both money and manpower, as exemplified by Company AB, into implementing new IT-systems that will ease governance (Venkatraman and Shantapriyan, 2013). Corporations want to use IT-governance in a way that supports their business objectives and achieves their goals (Prasad, Green, and Heales, 2012).

Finally, the added category of autonomy is likewise affected by IT-investments, especially when investigating companies who are not entirely self-dependent (Interview 7b). When a company is not able to decide which investment options to implement they are forced to take actions that might cripple their autonomy (Simoes, Biscaya, and Nevado, 2000). It is relevant for a company when evaluating a future IT-investment to consider the ramifications on their autonomy and ability to act as an independent business unit (Interview 7b).

The theory of technology debt can thus be applied on future IT-investments through categorization and measurement of future lock-ins. Another result of this study is that there might be specific categories important to specific companies, something that can be identified in a pre-study.

5.2. Discussion, study 2

2. How can technology debt support the choice between future IT-investment options?

Stemming from a real-option approach Company AB currently is in possession of two specific options, IO1 and IO2. As the applicability of option-theory is based on the assumption that the owner of an option always has the possibility not to exercise the option, this could be a possible option. In this case study that assumption would imply choosing neither option and instead keep working with the current system. However, this view does not exist in Company AB where the

original standpoint is that either IO1 or IO2 has to be chosen, as exemplified by interviewee 6 who claimed: "*Something has to be done (free translation)*" (Interview 6). (Other options might of course exist, yet they are not evaluated in this study and thus lie outside of this thesis). The real value of using a real option approach thus lies in its ability to inform management of their options (Balasubramanian, Kulatilaka, and Storck, 2000). Instead of valuing these two investment options in future cash-flows they are valued in future technology debt as presented below, in figure 5.1:

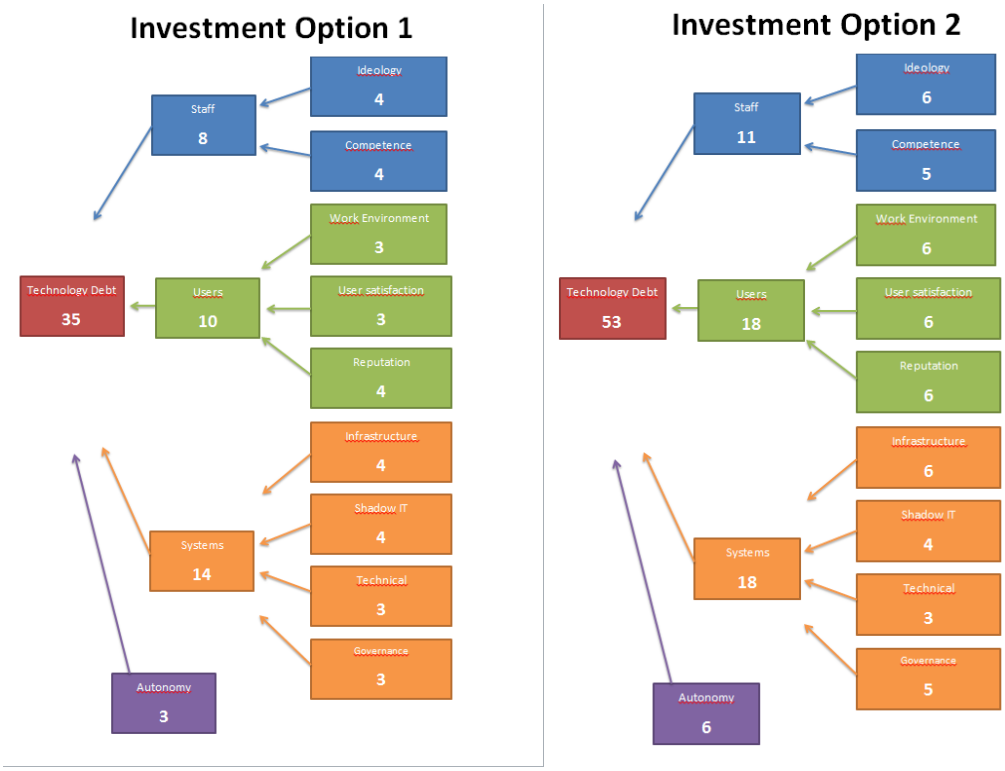

Figure 5.1 Investment options

Technology debt implies that there has to be some sort of future interest or other incurred costs, as stated by Magnusson and Bygstad (2014), measured in decreased maneuverability in future flexibility/options. Thus an increased technology debt will result in future negative cash-flows to manage this future loss of maneuverability.

An implementation of IO1 would decrease Company AB's technology debt in the following categories, as seen in figure 5.1 above; work environment, user satisfaction, technical debt, governance, and autonomy. Technology debt is unaltered in the following categories; ideology, competence, reputation, infrastructure, and shadow IT. Noticeable is that an implementation of IO1 would not increase technology debt in any of the measured category. An implementation of IO1 would thus increase future maneuverability.

Implementing IO2 would decrease Company AB's technology debt in the following category, as seen in figure 5.1 above; technical debt. Technology debt will remain unchanged in the following category; shadow IT. An implementation of IO2 would increase technology debt in the following categories; ideology, competence, work environment, user satisfaction, reputation, infrastructure, governance, and autonomy. As figure 5.1 visualizes, an implementation of IO2 would decrease future maneuverability.

Ideology: Some interviewees believed that IO1 would not increase the ideology of Company AB, whereas IO2 would create a strong ideological standard ex post. This is in line with the findings of Ven and Verelst (2008), and also West's (2003) claim that software vendors want you to get locked-in. This can be compared to the path-dependency exemplified by the case of Bell Atlantic and AT&T (Farrel and Klemperer, 2005).

Competence: In the case of IO2 there would be a slight increase in the concentration of competence as the company would be forced to recruit staff with relevant knowledge of IO2, according to some interviewees. As stated by Peréz-López and Alegre (2012) it is of outmost importance to manage the skillset of their employees.

Work environment: One interviewee said that the implementation of IO1 would at least give the IT-users a notion that they had a possibility to affect their work environment, something that is identified as important in the literature (Joseph et al., 2007). Joseph et al. (2007) also stress that employee's value the ability to influence the work environment. This influence would be lacking in the case of an IO2 implementation, according to some interviewees.

User satisfaction: Several researchers claim that ease of use inside a system is vital to user satisfaction (Davis, 1989; Venkatesh, 2000; Legris, Ingham, and Collerette, 2003; Calisir and Calisir, 2004). In the case of IO1, the interface would be new and fresh. However, there would be a small threshold getting used to it, something mentioned by several interviewees. In contrast, IO2 is considered complex and standardized resulting in decreased user satisfaction, according to some interviewees.

Reputation: Many interviewees have a negative perception of IO2 due to an unsuccessful implementation at another subsidiary within the corporate group. They all mentioned that IO2 has a very bad reputation in Sweden, something that affected their beliefs and attitudes towards IO2. Reich and Benbasat (2000) give weight to the alignment between previous implementations and reputation, yet in this case IO2 was considered suboptimal, thus creating future lock-ins.

IT-infrastructure: The interviewees were unsure how an implementation of IO1 would interact with the existing IT-infrastructure. Some believed that there is enough knowledge within the organization, while other interviewees believed that they lacked sufficient knowledge. Having

sufficient knowledge creates flexibility that further helps the organization act on business opportunities (Duncan, 1995) and is valued by the organization (Bharadwaj, 2000). Payoffs from IO1 are thus ambiguous as the interviewees are equally ambiguous concerning the knowledge within Company AB. IO2 is considered complex by the interviewees, something that implies inflexibility, and would increase costs to develop interfaces/modules. Comparing the comments regarding IO2 with the four purposes of IT-infrastructure presented by Nyrhinen (2006), see 3.1., IO2 appears to not fulfill any of these four purposes, especially as it is considered complex and cost generating.

Shadow IT: Both IO1 and IO2 are expected to introduce some new functions, yet in the case of IO1 it is not expected to influence the amount of shadow IT, according to some interviewees. Several interviewees state that IO2's complexity will cause some IT-users to use shadow IT in order to complete tasks already covered by functions in IO2. Research (Raden, 2005) claim that shadow IT develops when a function is not covered by the IT-system, however in this case shadow IT might be used even when it includes functions relevant to the users.

Technical: Technical debt is believed to decrease in Company AB as long as one of the options is chosen, according to the interviewees, since they are given a rare chance to remove old code that was implemented in the past. This is aligned with previous research (Parnas, 1994).

IT-governance: Prasad, Green, and Heales (2012) point out that the ideal IT-governance strategy sustains and extends the objectives and strategies of the firm. IO1 would make it slightly easier to govern using IT compared to IO2 which was assessed to decrease Company AB's ability to properly govern their IT-infrastructure. Effective IT-governance helps a corporation to ensure IT's value adding attributes, thus IO1 would be deemed more valuable. This is aligned with the findings of Reinhard (2012) and Marks (2010). However, the productivity paradox provides indications that IT-investments might not be as beneficial as previously believed (Brynjolfsson, 1993), perhaps this is due to poor IT-governance.

Autonomy: The notion that Company AB's autonomy would be affected by the implementation of either IO1 or IO2 was strongly supported by the interviewees as they identified vast differences compared with today. One interviewee stated that IO1 would liberate them of dependencies incurred by the parent company, which means that they would not be as crippled and their amount of lock-ins would decrease. Implementing IO2 would increase the integration within the corporate group and thus severely limit their autonomy and ability to act as an independent business unit, according to one interviewee. This statement is similar to Simoes, Biscaya, and Nevado's (2000) claim that subsidiaries can be forced to implement IT-investments that cripple their autonomy. The decision-making level (Weill and Ross, 2004a; Simonsson and Johnson, 2005) should be considered here as the parent company often wants control within the corporate group, whereas the subsidiary prefers autonomy (Birkinshaw et al., 2001). According

to Tiwana, Konsynski, and Venkatraman (2013) IT should enable distribution of decision-making abilities across organizational boundaries and allow autonomous units to exert authority and control. This stands in contrast with the opinions provided by several interviewees. A concern raised by Weill and Ross (2004b) is who should make decisions regarding IT-governance. Company AB experiences this problem as they are being subject to control by the parent company (Interview 7b). Linking this to institutional theory provide another viewpoint stating that individuals are not only shaped but also restrained by sharing systems and resources; working in such an environment will experience even more constraints (DiMaggio and Powell, 1983).

Returning to the evaluation of the two investment options, real-option theory implies that whatever option that results in the highest future cash-flow should be chosen (Fichman, 2004). Since IO1 would lead to less future costs with the implication that this translates to less negative cash-flows in the future compared to IO2, real-option theory implies that IO1 should be recommended.

Different future IT-investments can thus be compared using real-option theory, where each IT-investment's technology debt is measured. When properly valued these IT-investment options can support a decisions-maker, taking into consideration the implications for future lock-ins and (switching-) costs.

5.3. Discussion, study 3

3. How is technology debt relevant to decision-makers when facing IT-investment options?

To identify the relevance of technology debt for Company AB an evaluation was conducted with the CFO/CIO, as presented in 2.2.3. The evaluation produced a discussion regarding the parsimonious aspects, the operationality, and the empirical support of the results of the theory exploration and the interviews.

The CFO/CIO claimed that the theory and its underlying assumptions were defined within generally accepted parameters. Thus the theory is parsimonious in accordance with Swenson (1999). Noteworthy is that some of the interviewees experienced difficulties when discussing parts of the typology. This was considered negligible by the evaluator, as the results were still usable. The evaluator further deemed concepts well-defined and the process undertaken as appropriate so such an extent that (s)he would consider applying the framework again. Thus the theory is operational in practice. Both Swenson (1999) and Gregor (2006) state that an operational theory is usable on similar cases carried out by researchers. Considering the wide array of respondents in the case study, the results were considered to be empirically supported. Judgment and evaluation of the research findings (Corbin and Strauss, 1990; Eisenhardt and

Graebner, 2007) has thus been carried out and the empirical support was deemed as appropriate for the case study as it captured a wide range of opinions from different parts of the organization, according to the CFO/CIO.

Technology debt is relevant to decision-makers as it is able to capture the long-term effects in terms of future lock-ins for a future decision-maker, and serve as a complement to other measurements, such as implementation costs etc.

6. Conclusion

The conclusions of the thesis and the answer to the RQ are presented below. The implications for research and practice are also presented. Finally, suggestions for future research are given.

6.1. Conclusions

1. How can technology debt be applied to future IT-investment options?

Technology debt can be applied to future IT-investment options through a thorough categorization of possible future lock-ins caused by the investment. These categories need to be defined so that they are measurable by the organization in possession of the IT-investment options.

2. How can technology debt support the choice between future IT-investment options?

IT-investment options can be regarded as real-options. Through measuring each options based on their future level of technology debt they can be compared. This comparison supports the choice between future IT-investment options when properly valued, taking into consideration the implications for future lock-ins and (switching-) costs.

3. How is technology debt relevant to decision-makers when facing IT-investment options?

Technology debt is relevant to decision-makers as it captures the long-term effects, and can serve as a complement to other decision-tools.

RQ: How can technology debt be used when a company evaluates future IT-investment options?

As laid out in this thesis, technology debt can be used when evaluating future IT-investment options through a series of steps:

First, there is a presented categorization of the typology, identifying sources for future decision lock-ins caused by IT-investments. This categorization can serve as a starting-point when conducting future pre-studies. Pre-studies are a valuable tool to encounter problems and company specific consequences caused by the investment options.

Second, as a means to acquire both qualitative and quantitative results from the categorization, a series of interviews and measurements of future technology debt can be conducted. Through these measurements and interviews, decision-makers will be able to both visualize and

understand the reasoning behind the results. These results can then be viewed as real-options that with proper valuation will support decision-makers.

Third, decision-makers need to be given a chance to evaluate the results and consider technology debt as a relevant complement to other decision-tools.

By following these steps, IT-investment options can be evaluated through the usage of technology debt.

6.2. Implications for practice

This thesis presents a framework for decision-makers as they evaluate future IT-investments. It points out the importance of conducting a pre-study where company specific conditions can be identified. The main finding for practice is that technology debt is a viable complement to the evaluation of future IT-investments, as it captures the long-term effects of said investments. Technology debt is thus relevant to decision-makers. Identifying these future lock-ins and path-dependencies can help steer clear of future switching-costs and make decisions to balance the firms' amount of future debt. Through the use of real-option theory a comparison between the investment options' future technology debt can be carried out.

6.3. Implications for research

The case study conducted has served as a theory test and expanded the original theory of technology debt. Real-option theory is a feasible approach when valuing investments of this nature, as suggested by Amram and Kulatilaka (1998). In line with Kumar (2002) there is a need for an alternative valuation method for this kind of investment options. As mentioned by researchers related to institutional theory (DiMaggio and Powell, 1983), there are certain elements that imply that the rooted values of the organization limit their ability to make rational business-decisions.

6.4. Future research

- According to Jensen and Meckling (1976), debt is a necessary element of the capital structure of the corporation. Through valuing technology debt in monetary terms it can be included in the capital structure. Valuation would help visualize future path-dependency (Arthur, 1994; Kim and Sanders, 2002; List, 2004) and lock-in(s) (Shapiro and Varian, 1999). By further intertwining technology debt and financial theory (Magnusson and Bygstad, 2014; Allman, 2012) future researchers could find a way to properly include it in the capital structure and further monetize the interest rate. One approach to this is to further study the valuation of real-options (Amram and Kulatilaka 1998; Kumar, 2002; Fichman, 2004).

- During the conducted workshop with the CIO/CFO another possible source of technology debt was identified, which lead to the category autonomy. This source of technology debt came from the consequences that would occur to Company AB if they were discarded from the corporate structure. As mentioned during Interview 7b: what would happen to the subsidiary if they were forced to live with a new IT-infrastructure heavily enforced by the parent company without the future support of the parent company? Interesting approaches to this could be to further research the consequences caused by a subsidiary being forced to adapt policies developed by the parent company. Further identifying lock-in(s) and long-term effects by these decisions. Another approach is to continue to develop a category for these sources of debt e.g. 'Corporation', where autonomy could be a starting point.

- Technology debt can function as a performance indicator in a balanced scorecard including IT as a new perspective as suggested by several researchers (Weill and Ross, 2004; van Grembergen, 2000; van Grembergen and De Haes, 2004) IT is an important part of many organizations and thus their impact and contribution can be identified in many ways. A balanced scorecard would include other key performance indicators (Van Der Zee and De Jong, 1999; Martinsons, Davison and Tse, 1999), as well as technology debt. Further research could focus on including technology debt and test the applicability in a balanced scorecard environment.

Aside from these suggestions, further theory testing in the form of more case studies could contribute other valuable inputs and aspects not considered in this thesis.

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Interviews

Interview 1. 2014. Interviewed by Anton Johansson and Christian Widell, 30 April.

Interview 2. 2014. Interviewed by Anton Johansson and Christian Widell, 30 April.

Interview 3. 2014. Interviewed by Anton Johansson and Christian Widell, 30 April.

Interview 4. 2014. Interviewed by Anton Johansson and Christian Widell, 30 April.

Interview 5. 2014. Interviewed by Anton Johansson and Christian Widell, 30 April.

Interview 6. 2014. Interviewed by Anton Johansson and Christian Widell, 30 April.

Interview 7a. 2014. Interviewed by Anton Johansson and Christian Widell, 14 April.

Interview 7b (workshop). 2014. Interviewed by Anton Johansson and Christian Widell, 25 April.

Interview 7c. 2014. Interviewed by Anton Johansson and Christian Widell, 16 May.

Interview 8. 2014. Interviewed by Anton Johansson and Christian Widell, 5 May.

Interview 9. 2014. Interviewed by Anton Johansson and Christian Widell, 5 May.

8. Appendix

8.1. Appendix A (Interviews)

Questionnaires from the interviews at Company AB

Questionnaire regarding technology debt in Company AB

1. Background

Name: *Interviewee 1*

Email address: *Interviewee.1@company.se*

Age: *54 years*

How many years have you worked at Company AB? *11 years*
At current position? *2 years*

Before starting at Company AB, what was your experience within the field of IT-systems?
(S)he has been working as a system developer since 1985

Professional title: *System Developer*

On a day-to-day basis, how do you come in contact with the IT-systems in the company?
(S)he has been working with system development and programming. Also has some responsibility within some of the systems.

What is your general opinion regarding the two alternative investment options?
(S)he has some bad experiences with IO2 due to a previous implementation at another company. The general opinion regarding IO1 is that Company AB will become more flexible with this system.

2. Identification and measurement of technology debt

Technology debt is defined as: “Accumulated obligation owned by current CIO (debtor) to future CIO (creditor), where previous decisions limit prospective decisions (Magnusson and Bygstad, 2014)”.
How will company AB’s technology debt be affected, using the following ten categories as a framework? You are also requested to evaluate the impact the investment options have on the technology debt on a scale 1-7, where 7 implies a greatly increased technology debt, 4 equals no change in debt, 1 implies a greatly decreased technology debt.

Category	Investment option 1 (IO1)	Investment option 2 (IO2)
Ideology among **IT-staff** *The IT-staff possess certain preferences/bias regarding choice of software or system etc. Will a future CIO be forced to make a decision based on ideology instead of a rational decision?*	As it is today, no change 1 2 3 **4** 5 6 7	No change in ideology among the IT-staff 1 2 3 **4** 5 6 7
Competence among **IT-staff** *IT-staff tend to possess specific IT-competence. Will the investment cause a concentration of competence and/or influence future CIO’s recruitment process?*	Same concentration in competence among the IT-staff as today 1 2 3 **4** 5 6 7	Same concentration in competence among the IT-staff as today 1 2 3 **4** 5 6 7
Working environment for **users** of the IT-systems *How will the working environment/atmosphere be affected by the investment? For example impact on user’s ability to influence the IT-system.*	New system, will affect the conservative IT-users negative 1 2 3 4 **5** 6 7	The effects from a implementation will tear hard on the working environment among the IT-users 1 2 3 4 5 6 **7**

Category	Investment option 1	Investment option 2
User satisfaction among employees who use IT *Usability of the system, e.g. simplicity of the user interface and so on. How do you think that the investment will affect the usage of the IT-system?*	New system, will be hard in the beginning 1 2 3 4 **5** 6 7	Complex system, will work in either system as it is in their job description 1 2 3 4 5 **6** 7
Reputation of the investment among **users** of the IT-system *This involves perception of the investment option regarding; reliability, requirements, and service-level. Is there a reputation that affects the willingness to use the investment option?*	No specific reputation 1 2 3 **4** 5 6 7	IO2 got a bad reputation among the IT-users, mainly because a failure of implementation at a sister company within the corporate group 1 2 3 4 5 6 **7**
System-infrastructure *Cooperation between the IT-system and the various interfaces and modules. How will time, cost and knowledge affect development of internal interfaces and modules?*	Same as today 1 2 3 **4** 5 6 7	Same as today 1 2 3 **4** 5 6 7
Shadow IT *Shadow IT refers to user-driven innovation caused by a lack of functionality of the IT-system. E.g. internal excel macros.* *Will the investment increase or decrease the amount of shadow IT in the company?*	Same as today 1 2 3 **4** 5 6 7	Same as today 1 2 3 **4** 5 6 7

Category	Investment option 1	Investment option 2
Technical debt *This encompasses current programming of the IT-system, quality of its documentation and the thoroughness of previous programming. How will the investments affect the technical debt with regard to interfaces and other functions linked to the IT-system?*	A lot of old, bad documented code today that can be removed with the implementation of IO1 1 **2** 3 4 5 6 7	A lot of old, bad documented code today that can be removed with the implementation of IO2 1 **2** 3 4 5 6 7
Governance using the IT-system *How will the investment influence the company's ability to control through IT? Possible adaptability to organizational change with the help of the IT-system.*	With the implementation of IO1, Company AB will be able to govern more with the use of IT compared with today 1 **2** 3 4 5 6 7	Locked-in by the template, can't use the IT-system to govern because of this 1 2 3 4 5 6 **7**
Autonomy *What lock-ins will the investment option cause on the organizations ability to perform as an autonomous unit?*	With the implementation of IO1, a lot of old lock-ins can be removed 1 2 **3** 4 5 6 7	The template will destroy the possibility to perform as an autonomous unit 1 2 3 4 5 **6** 7

3. Final questions

Are these ten categories enough to evaluate the effect on technology debt caused by these two investment options? Why/Why not?

The aspect of implementation costs should be evaluated, for example the cost of educating the IT-staff and users.

Other additions or thoughts?

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Questionnaire regarding technology debt in Company AB

1. Background

Name: *Interviewee 2*

Email address: *Interviewee.2@company.se*

Age: *50 years*
How many years have you worked at Company AB? *5 years*
At current position? *5 years*

Before starting at Company AB, what was your experience within the field of IT-systems?
(S)he has been working with IT-systems since the mid 80's

Professional title: *Accounting manager*

On a day-to-day basis, how do you come in contact with the IT-systems at the company?
Establishing reports and searching for information to assist our operations

What is your general opinion regarding the two alternative investment options?
None of the investment options will be a walk in the park

2. Identification and measurement of technology debt

Technology debt is defined as: “Accumulated obligation owned by current CIO (debtor) to future CIO (creditor), where previous decisions limit prospective decisions (Magnusson and Bygstad, 2014)”.
How will company AB’s technology debt be affected, using the following ten categories as a framework? You are also requested to evaluate the impact the investment options have on the technology debt on a scale 1-7, where 7 implies a greatly increased technology debt, 4 equals no change in debt, 1 implies a greatly decreased technology debt.

Category	Investment option 1 (IO1)	Investment option 2 (IO2)
Ideology among **IT-staff** *The IT-staff possess certain preferences/bias regarding choice of software or system etc. Will a future CIO be forced to make a decision based on ideology instead of a rational decision?*	The ideology will be stronger 1 2 3 4 **5** 6 7	No change from today 1 2 3 **4** 5 6 7
Competence among **IT-staff** *IT-staff tend to possess specific IT-competence. Will the investment cause a concentration of competence and/or influence future CIO’s recruitment process?*	Same concentration in competence among the IT-staff as today 1 2 3 **4** 5 6 7	A slightly stronger concentration of competence among the IT-staff 1 2 3 4 **5** 6 7
Working environment for **users** of the IT-systems *How will the working environment/atmosphere be affected by the investment? For example impact on user’s ability to influence the IT-system.*	The user will have a stronger influence on the IT-system than today 1 2 **3** 4 5 6 7	Users will have problems influencing the IT-system, you will need a thick frontal bone to be able to do so 1 2 3 4 5 **6** 7

Category	Investment option 1	Investment option 2
User satisfaction among employees who use IT *Usability of the system, e.g. simplicity of the user interface and so on. How do you think that the investment will affect the usage of the IT-system?*	Have not seen the interface, neutral 1 2 3 **4** 5 6 7	Frustration among the users because of the complex interface 1 2 3 4 5 **6** 7
Reputation of the investment among **users** of the IT-system *This involves perception of the investment option regarding; reliability, requirements, and service-level. Is there a reputation that affects the willingness to use the investment option?*	The users recognize the IO1's name, not totally unfamiliar 1 2 **3** 4 5 6 7	IO2 got an infamous name in Sweden, a lot of business administrators say "run the other way" when they hear IO2's name 1 2 3 4 5 6 **7**
System-infrastructure *Cooperation between the IT-system and the various interfaces and modules. How will time, cost and knowledge affect development of internal interfaces and modules?*	Troublesome to switch IT-system, will have a negative aspect on the infrastructure 1 2 3 4 5 **6** 7	Troublesome to switch IT-system, will have a negative aspect on the infrastructure 1 2 3 4 5 **6** 7
Shadow IT *Shadow IT refers to user-driven innovation caused by a lack of functionality of the IT-system. E.g. internal excel macros.* *Will the investment increase or decrease the amount of shadow IT in the company?*	Can remove a lot of Shadow-it that is existent today 1 2 **3** 4 5 6 7	IO2 is very extensive, will cover more than the current IT-system 1 2 **3** 4 5 6 7

Category	Investment option 1	Investment option 2
Technical debt *This encompasses current programming of the IT-system, quality of its documentation and the thoroughness of previous programming. How will the investments affect the technical debt with regard to interfaces and other functions linked to the IT-system?*	A lot of old code that is “hardcoded” will be removed with the implementation of IO1 1 2 **3** 4 5 6 7	A lot of old code that is “hardcoded” will be removed with the implementation of IO2 1 2 **3** 4 5 6 7
Governance using the IT-system *How will the investment influence the company’s ability to control through IT? Possible adaptability to organizational change with the help of the IT-system.*	IO1 can be used to govern the organization to a higher degree than the current IT-system can 1 **2** 3 4 5 6 7	IO2 can be used to govern the organization to a higher degree than the current IT-system can 1 **2** 3 4 5 6 7
Autonomy *What lock-ins will the investment option cause on the organizations ability to perform as an autonomous unit?*	Increased possibility to work as an autonomous unit than today 1 2 **3** 4 5 6 7	Huge lock-in due to decision-making being out of Company AB’s control 1 2 3 4 5 **6** 7

3. Final questions

Are these ten categories enough to evaluate the effect on technology debt caused by these two investment options? Why/Why not?

(S)he thinks that the purpose here is to capture a wide array of concerns with only a few questions, similar to the Pareto-principle. Cover 80% by asking about 20%.

Other additions or thoughts?

-

Questionnaire regarding technology debt in Company AB

1. Background

Name: *Interviewee 3*

Email address: *Interviewee.3@company.se*

Age: *42 years*
How many years have you worked at Company AB? *7 years*
At current position? *7 years*

Before starting at Company AB, what was your experience within the field of IT-systems?
(S)he has been working with IT-systems at various different companies since 1996. Had an implementation of a huge ERP-system at a previous employer, similar to IO2

Professional title: *Controller*

On a day-to-day basis, how do you come in contact with the IT-systems at the company?
(S)he uses the IT-system to do all sorts of reports

What is your general opinion regarding the two alternative investment options?
(S)he has previous experience with an implementation of an ERP-system similar to IO2. This implementation has affected his/her general opinion about IO2 in a negative way

2. Identification and measurement of technology debt

Technology debt is defined as: “Accumulated obligation owned by current CIO (debtor) to future CIO (creditor), where previous decisions limit prospective decisions (Magnusson and Bygstad, 2014)”.
How will company AB’s technology debt be affected, using the following ten categories as a framework? You are also requested to evaluate the impact the investment options have on the technology debt on a scale 1-7, where 7 implies a greatly increased technology debt, 4 equals no change in debt, 1 implies a greatly decreased technology debt.

Category	Investment option 1 (IO1)	Investment option 2 (IO2)
Ideology among **IT-staff** *The IT-staff possess certain preferences/bias regarding choice of software or system etc. Will a future CIO be forced to make a decision based on ideology instead of a rational decision?*	No change from today 1 2 3 **4** 5 6 7	Harder for a future decision-maker to make a rational decision due to a strengthened ideology among the IT-staff 1 2 3 4 **5** 6 7
Competence among **IT-staff** *IT-staff tend to possess specific IT-competence. Will the investment cause a concentration of competence and/or influence future CIO’s recruitment process?*	Same concentration in competence among the IT-staff compared with today 1 2 3 **4** 5 6 7	Same concentration in competence among the IT-staff as today 1 2 3 **4** 5 6 7
Working environment for **users** of the IT-systems *How will the working environment/atmosphere be affected by the investment? For example impact on user’s ability to influence the IT-system.*	The users will have a stronger influence on the IT-system than current system 1 2 **3** 4 5 6 7	Due to a strong lock-in with IO2, the working environment will be negatively impacted 1 2 3 4 5 **6** 7

Category	Investment option 1	Investment option 2
User satisfaction among employees who use IT *Usability of the system, e.g. simplicity of the user interface and so on. How do you think that the investment will affect the usage of the IT-system?*	The IO1's user interface will be new and fresh, this will raise the user satisfaction 1 2 **3** 4 5 6 7	Since IO2 is a standardized system, the user interface will not be optimal for Company AB's IT-users, a lot worse than today 1 2 3 4 5 **6** 7
Reputation of the investment among **users** of the IT-system *This involves perception of the investment option regarding; reliability, requirements, and service-level. Is there a reputation that affects the willingness to use the investment option?*	A good reputation among the IT-users 1 2 **3** 4 5 6 7	Since the IT-users have seen the problems the sister company has experienced, it has a bad reputation that will affect the willingness to use IO2 1 2 3 4 5 **6** 7
System-infrastructure *Cooperation between the IT-system and the various interfaces and modules. How will time, cost and knowledge affect development of internal interfaces and modules?*	Easier to influence the supplier of IO1 1 2 **3** 4 5 6 7	More complex to adjust to our specific needs 1 2 3 4 5 **6** 7
Shadow IT *Shadow IT refers to user-driven innovation caused by a lack of functionality of the IT-system. E.g. internal excel macros.* *Will the investment increase or decrease the amount of shadow IT in the company?*	Same as today 1 2 3 **4** 5 6 7	There will be a stronger need than today to use shadow-IT due to the ability generate reports is suboptimal in IO2 1 2 3 4 5 **6** 7

Category	Investment option 1	Investment option 2
Technical debt *This encompasses current programming of the IT-system, quality of its documentation and the thoroughness of previous programming. How will the investments affect the technical debt with regard to interfaces and other functions linked to the IT-system?*	A lot of old code will be removed with the implementation of IO1 1 2 **3** 4 5 6 7	A lot of old code will be removed with the implementation of IO2 1 2 **3** 4 5 6 7
Governance using the IT-system *How will the investment influence the company's ability to control through IT? Possible adaptability to organizational change with the help of the IT-system.*	IO1 will have new functions that will help the governing of the organization with the help of IT 1 2 **3** 4 5 6 7	To be able to govern the organization the company will need shadow-IT to a larger extent. 1 2 3 4 **5** 6 7
Autonomy *What lock-ins will the investment option cause on the organizations ability to perform as an autonomous unit?*	Because the flexibility that IO1 supplies, Company AB will be able to act as an autonomous unit more effectively than before 1 **2** 3 4 5 6 7	Company AB will have a decrease in the possibility to act as an autonomous unit due to the template that is enforced by the mother company 1 2 3 4 5 **6** 7

3. Final questions

Are these ten categories enough to evaluate the effect on technology debt caused by these two investment options? Why/Why not?

(S)he believes some categories were hard to understand, for example ideology

Other additions or thoughts?

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Questionnaire regarding technology debt in Company AB

1. Background

Name: *Interviewee 4*

Email address: *Interviewee.4@company.se*

Age: *44 years*
How many years have you worked at Company AB? *2 years*
At current position? *2 years*

Before starting at Company AB, what was your experience within the field of IT-systems?
(S)he has been working with IT-systems since the beginning of my professional career

Professional title: *System developer*

On a day-to-day basis, how do you come in contact with the IT-systems at the company?
(S)he works with the support in the systems, but also has charge of the strategic view for some of the systems within Company AB

What is your general opinion regarding the two alternative investment options?
(S)he thinks that something has to be done and that the current IT-system is outdated. IO2 seems problematic and complex from what (s)he has heard

2. Identification and measurement of technology debt

Technology debt is defined as: “Accumulated obligation owned by current CIO (debtor) to future CIO (creditor), where previous decisions limit prospective decisions (Magnusson and Bygstad, 2014)”.
How will company AB’s technology debt be affected, using the following ten categories as a framework? You are also requested to evaluate the impact the investment options have on the technology debt on a scale 1-7, where 7 implies a greatly increased technology debt, 4 equals no change in debt, 1 implies a greatly decreased technology debt.

Category	Investment option 1 (IO1)	Investment option 2 (IO2)
Ideology among **IT-staff** *The IT-staff possess certain preferences/bias regarding choice of software or system etc. Will a future CIO be forced to make a decision based on ideology instead of a rational decision?*	No change from today 1 2 3 **4** 5 6 7	Harder for a future decision-maker to make a rational decision due to a stronger ideology among the IT-staff 1 2 3 4 **5** 6 7
Competence among **IT-staff** *IT-staff tend to possess specific IT-competence. Will the investment cause a concentration of competence and/or influence future CIO’s recruitment process?*	Same concentration in competence among the IT-staff similar to current staff 1 2 3 **4** 5 6 7	Easier for a future CIO’s in his recruitment process due to IO2 being a widely used IT-system 1 2 **3** 4 5 6 7
Working environment for **users** of the IT-systems *How will the working environment/atmosphere be affected by the investment? For example impact on user’s ability to influence the IT-system.*	Since the old IT-system is outdated, a new IT-system will improve the working environment because the IT-users will have a stronger impact on its development 1 **2** 3 4 5 6 7	The IT-users will have a greater influence on the development of the IT-system than of today 1 2 **3** 4 5 6 7

Category	Investment option 1	Investment option 2
User satisfaction among employees who use IT *Usability of the system, e.g. simplicity of the user interface and so on. How do you think that the investment will affect the usage of the IT-system?*	With a modern system the user satisfaction will go up due to a simpler user interface 1 **2** 3 4 5 6 7	With a modern system the user satisfaction will increase due to a simpler user interface 1 **2** 3 4 5 6 7
Reputation of the investment among **users** of the IT-system *This involves perception of the investment option regarding; reliability, requirements, and service-level. Is there a reputation that affects the willingness to use the investment option?*	The IT-users think that IO1 is not the most suitable choice in the organization 1 2 3 4 **5** 6 7	Due to the problematic implementation of IO2 at the sister company, IO2 has a bad reputation 1 2 3 4 **5** 6 7
System-infrastructure *Cooperation between the IT-system and the various interfaces and modules. How will time, cost and knowledge affect development of internal interfaces and modules?*	There is knowledge within the company that will reduce the cost and time of the development of internal interfaces and modules 1 2 **3** 4 5 6 7	The time and cost will be increased when developing internal interfaces and modules to such a different system 1 2 3 4 5 **6** 7
Shadow IT *Shadow IT refers to user-driven innovation caused by a lack of functionality of the IT-system. E.g. internal excel macros. Will the investment increase or decrease the amount of shadow IT in the company?*	Same as today 1 2 3 **4** 5 6 7	Same as today 1 2 3 **4** 5 6 7

Category	Investment option 1	Investment option 2
Technical debt *This encompasses current programming of the IT-system, quality of its documentation and the thoroughness of previous programming. How will the investments affect the technical debt with regard to interfaces and other functions linked to the IT-system?*	Same as today 1 2 3 **4** 5 6 7	Same as today 1 2 3 **4** 5 6 7
Governance using the IT-system *How will the investment influence the company's ability to control through IT? Possible adaptability to organizational change with the help of the IT-system.*	Due to the old IT-system being outdated, the new system will bring functions that will help governing using IT 1 **2** 3 4 5 6 7	Due to the old IT-system being outdated, the new system will bring functions that will help governing using IT 1 **2** 3 4 5 6 7
Autonomy *What lock-ins will the investment option cause on the organizations ability to perform as an autonomous unit?*	The same ability to work as an autonomous unit as currently 1 2 3 **4** 5 6 7	The same ability to work as an autonomous unit as currently 1 2 3 **4** 5 6 7

3. Final questions

Are these ten categories enough to evaluate the effect on technology debt caused by these two investment options? Why/Why not?

(S)he thinks that this new aspect has not been given much thought previously, and it is a relevant aspect because the information regarding what happens on the long term is vital, if a company wants to stay in business

Other additions or thoughts?

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Questionnaire regarding technology debt in Company AB

1. Background

Name: *Interviewee 5*

Email address: *Interviewee.5@company.se*

Age: *56 years*
How many years have you worked at Company AB? *27 years*
At current position? *14 years*

Before starting at Company AB, what was your experience within the field of IT-systems?
(S)he has been working with IT-systems since the arrival at Company AB

Professional title: *System administrator*

On a day-to-day basis, how do you come in contact with the IT-systems at the company?
(S)he works with training and support for system users. External contact through internal systems

What is your general opinion regarding the two alternative investment options?
(S)he believes that IO2 should be avoided and that IO1 is much better

2. Identification and measurement of technology debt

Technology debt is defined as: “Accumulated obligation owned by current CIO (debtor) to future CIO (creditor), where previous decisions limit prospective decisions (Magnusson and Bygstad, 2014)”.
How will company AB’s technology debt be affected, using the following ten categories as a framework? You are also requested to evaluate the impact the investment options have on the technology debt on a scale 1-7, where 7 implies a greatly increased technology debt, 4 equals no change in debt, 1 implies a greatly decreased technology debt.

Category	Investment option 1 (IO1)	Investment option 2 (IO2)
Ideology among **IT-staff** *The IT-staff possess certain preferences/bias regarding choice of software or system etc. Will a future CIO be forced to make a decision based on ideology instead of a rational decision?*	No change from today 1 2 3 **4** 5 6 7	If IO2 is implemented, it would be considered the standard from that moment on, increasing ideology severely 1 2 3 4 5 6 **7**
Competence among **IT-staff** *IT-staff tend to possess specific IT-competence. Will the investment cause a concentration of competence and/or influence future CIO’s recruitment process?*	Similar concentration in competence among the IT-staff 1 2 3 **4** 5 6 7	Stronger concentration in competence among the IT-staff similar to current staff 1 2 3 4 5 **6** 7
Working environment for **users** of the IT-systems *How will the working environment/atmosphere be affected by the investment? For example impact on user’s ability to influence the IT-system.*	No change from today 1 2 3 **4** 5 6 7	Many routines will not be as flexible 1 2 3 4 **5** 6 7

Category	Investment option 1	Investment option 2
User satisfaction among employees who use IT *Usability of the system, e.g. simplicity of the user interface and so on. How do you think that the investment will affect the usage of the IT-system?*	The user interface will be a lot easier to work with compared with the IT-system that Company AB uses today 1 **2** 3 4 5 6 7	A modern system will be more flexible, yet IO2 is not suitable with Company AB 1 2 3 4 5 **6** 7
Reputation of the investment among **users** of the IT-system *This involves perception of the investment option regarding; reliability, requirements, and service-level. Is there a reputation that affects the willingness to use the investment option?*	There is a reputation among the IT-users that IO1 is new and up to date 1 2 **3** 4 5 6 7	Complex and hard to work with, bad reputation 1 2 3 4 **5** 6 7
System-infrastructure *Cooperation between the IT-system and the various interfaces and modules. How will time, cost and knowledge affect development of internal interfaces and modules?*	No change from today 1 2 3 **4** 5 6 7	Will take a considerable amount of time, it contains so much more than previous systems 1 2 3 4 5 6 **7**
Shadow IT *Shadow IT refers to user-driven innovation caused by a lack of functionality of the IT-system. E.g. internal excel macros.* *Will the investment increase or decrease the amount of shadow IT in the company?*	A small decrease compared to today 1 2 **3** 4 5 6 7	A new report generator will have a positive impact 1 **2** 3 4 5 6 7

Category	Investment option 1	Investment option 2
Technical debt *This encompasses current programming of the IT-system, quality of its documentation and the thoroughness of previous programming. How will the investments affect the technical debt with regard to interfaces and other functions linked to the IT-system?*	Decreased level of technical debt. 1 2 **3** 4 5 6 7	More interfaces to work with 1 **2** 3 4 5 6 7
Governance using the IT-system *How will the investment influence the company's ability to control through IT? Possible adaptability to organizational change with the help of the IT-system.*	No change from today 1 2 3 **4** 5 6 7	No change from today 1 2 3 **4** 5 6 7
Autonomy *What lock-ins will the investment option cause on the organizations ability to perform as an autonomous unit?*	No change from today 1 2 3 **4** 5 6 7	Increased integration into the corporate group, decreasing their self-dependence 1 2 3 4 5 **6** 7

3. Final questions

Are these ten categories enough to evaluate the effect on technology debt caused by these two investment options? Why/Why not?

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Other additions or thoughts?

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Questionnaire regarding technology debt in Company AB

1. Background

Name: *Interviewee 6*

Email address: *Interviewee.6@company.se*

Age: *53 years*
How many years have you worked at Company AB? *6 years*
At current position? *6 years*

Before starting at Company AB, what was your experience within the field of IT-systems?
Been working with IT-systems since 1998

Professional title: *System developer*

On a day-to-day basis, how do you come in contact with the IT-systems at the company?
(S)he works with specifying what the programmers are supposed to do. (S)he also handles the bug reports from the systems connected to the business administration

What is your general opinion regarding the two alternative investment options?
IO1 would not work properly without additions, but still (s)he prefers IO1 since IO2 would not work at all without substantial changes to the template

2. Identification and measurement of technology debt

Technology debt is defined as: “Accumulated obligation owned by current CIO (debtor) to future CIO (creditor), where previous decisions limit prospective decisions (Magnusson and Bygstad, 2014)”.
How will company AB’s technology debt be affected, using the following ten categories as a framework? You are also requested to evaluate the impact the investment options have on the technology debt on a scale 1-7, where 7 implies a greatly increased technology debt, 4 equals no change in debt, 1 implies a greatly decreased technology debt.

Category	Investment option 1 (IO1)	Investment option 2 (IO2)
Ideology among **IT-staff** *The IT-staff possess certain preferences/bias regarding choice of software or system etc. Will a future CIO be forced to make a decision based on ideology instead of a rational decision?*	No change from today 1 2 3 **4** 5 6 7	Harder for a future decision-maker to make a rational decision due to a stronger ideology among the IT-staff 1 2 3 4 5 **6** 7
Competence among **IT-staff** *IT-staff tend to possess specific IT-competence. Will the investment cause a concentration of competence and/or influence future CIO’s recruitment process?*	Less concentration in competence among the IT-staff similar to current staff 1 2 **3** 4 5 6 7	Stronger concentration in competence among the IT-staff similar to current staff 1 2 3 4 **5** 6 7
Working environment for **users** of the IT-systems *How will the working environment/atmosphere be affected by the investment? For example impact on user’s ability to influence the IT-system.*	There will at least be a feeling among the IT-users that they have an impact on IO1’s development 1 2 **3** 4 5 6 7	The IT-users will not have any influence of the development of the IT-system with IO2 1 2 3 4 5 6 **7**

Category	Investment option 1	Investment option 2
User satisfaction among employees who use IT *Usability of the system, e.g. simplicity of the user interface and so on. How do you think that the investment will affect the usage of the IT-system?*	Long term IO1 will have a user interface that the IT-users will be more satisfied with than the current one 1 **2** 3 4 5 6 7	IO2 has a complex user interface that will have a negative effect on the IT-users and their satisfaction with the system 1 2 3 4 5 6 **7**
Reputation of the investment among **users** of the IT-system *This involves perception of the investment option regarding; reliability, requirements, and service-level. Is there a reputation that affects the willingness to use the investment option?*	There is a perception among the IT-users that IO1 will be a huge improvement when comparing with the current IT-system 1 **2** 3 4 5 6 7	Due to the problematic implementation of IO2 at the sister company, IO2 has a bad reputation. The IT-users know that IO2 is not developed for their kind of industry 1 2 3 4 5 6 **7**
System-infrastructure *Cooperation between the IT-system and the various interfaces and modules. How will time, cost and knowledge affect development of internal interfaces and modules?*	Insufficient knowledge on how to develop the internal interfaces and modules that will cause the development of new interfaces etc. to be more costly than today 1 2 3 4 **5** 6 7	Insufficient knowledge on how to develop the internal interfaces and modules that will cause the development of new interfaces etc. to be more costly than today 1 2 3 4 5 **6** 7
Shadow IT *Shadow IT refers to user-driven innovation caused by a lack of functionality of the IT-system. E.g. internal excel macros.* *Will the investment increase or decrease the amount of shadow IT in the company?*	IO1 will cover some functions that today is covered by shadow IT 1 2 **3** 4 5 6 7	Since IO2 is to complex and hard to use, IT-users will use shadow IT in a wider spread than of today 1 2 3 4 5 6 **7**

Category	Investment option 1	Investment option 2
Technical debt *This encompasses current programming of the IT-system, quality of its documentation and the thoroughness of previous programming. How will the investments affect the technical debt with regard to interfaces and other functions linked to the IT-system?*	With the implementation of IO1 a lot of old, bad quality code will be removed 1 **2** 3 4 5 6 7	With the implementation of IO2 a lot of old, bad quality code will be removed 1 **2** 3 4 5 6 7
Governance using the IT-system *How will the investment influence the company's ability to control through IT? Possible adaptability to organizational change with the help of the IT-system.*	Due to the flexibility within IO1, Company AB will be able to govern its organization to a larger extent than before with the use of IT 1 **2** 3 4 5 6 7	Because of the template that is being enforced, Company AB will not be able to govern its organization as before 1 2 3 4 5 6 **7**
Autonomy *What lock-ins will the investment option cause on the organizations ability to perform as an autonomous unit?*	With the implementation of IO1, Company AB will not be locked-in by some of the systems, as it is today 1 2 **3** 4 5 6 7	Due to the template and that IO2 is not developed for Company AB's industry, there will be a huge lock-in on the ability to perform as an autonomous unit 1 2 3 4 5 6 **7**

3. Final questions

Are these ten categories enough to evaluate the effect on technology debt caused by these two investment options? Why/Why not?

If this approach (technology debt) is seen as a complement to other forms of evaluations, and contributes to a better understanding of past decisions, it is useful.

Other additions or thoughts?

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Questionnaire regarding technology debt in Company AB

1. Background

Name: *Interviewee 7*

Email address: *Interviewee.7@company.se*

Age: *54 years*
How many years have you worked at Company AB? *34 years*
At current position? *7 years*

Before starting at Company AB, what was your experience within the field of IT-systems?
-

Professional title: *Director of administration*

On a day-to-day basis, how do you come in contact with the IT-systems at the company?
(S)he has the main responsibility of the IT-systems within Company AB

What is your general opinion regarding the two alternative investment options?
(S)he is opposed to the implementation of IO2

2. Identification and measurement of technology debt

Technology debt is defined as: “Accumulated obligation owned by current CIO (debtor) to future CIO (creditor), where previous decisions limit prospective decisions (Magnusson and Bygstad, 2014)”.
How will company AB’s technology debt be affected, using the following ten categories as a framework? You are also requested to evaluate the impact the investment options have on the technology debt on a scale 1-7, where 7 implies a greatly increased technology debt, 4 equals no change in debt, 1 implies a greatly decreased technology debt.

Category	Investment option 1 (IO1)	Investment option 2 (IO2)
Ideology among **IT-staff** *The IT-staff possess certain preferences/bias regarding choice of software or system etc. Will a future CIO be forced to make a decision based on ideology instead of a rational decision?*	With the implementation of IO1 a future CIO will have a smoother transition. Rational decisions will not be influenced by ideology compared with today 1 **2** 3 4 5 6 7	With the implementation of IO2 a future CIO will be forced to act according to a new ideology 1 2 3 4 5 6 **7**
Competence among **IT-staff** *IT-staff tend to possess specific IT-competence. Will the investment cause a concentration of competence and/or influence future CIO’s recruitment process?*	Less concentration in competence among the IT-staff similar to current staff 1 2 **3** 4 5 6 7	Wider array of skills in the company, however development will be centralized 1 **2** 3 4 5 6 7
Working environment for **users** of the IT-systems *How will the working environment/atmosphere be affected by the investment? For example impact on user’s ability to influence the IT-system.*	Ability to adjust the system to specific needs will enhance the environment 1 2 **3** 4 5 6 7	With the implementation of IO2 there will be frustration among IT-users due to the lack of flexibility 1 2 3 4 5 6 **7**

Category	Investment option 1	Investment option 2
User satisfaction among employees who use IT *Usability of the system, e.g. simplicity of the user interface and so on. How do you think that the investment will affect the usage of the IT-system?*	No change compared with today 1 2 3 **4** 5 6 7	Complex user interface within IO2 will increase the usage of other systems 1 2 3 4 **5** 6 7
Reputation of the investment among **users** of the IT-system *This involves perception of the investment option regarding; reliability, requirements, and service-level. Is there a reputation that affects the willingness to use the investment option?*	There will be no change in willingness to use the system 1 2 3 **4** 5 6 7	IO2 has a very bad reputation within the company. Mainly due to past failures within the corporate group 1 2 3 4 5 **6** 7
System-infrastructure *Cooperation between the IT-system and the various interfaces and modules. How will time, cost and knowledge affect development of internal interfaces and modules?*	No visible changes compared with today 1 2 3 **4** 5 6 7	Will not effectively cooperate with current infrastructure. Very expensive to develop internal interfaces 1 2 3 4 5 6 **7**
Shadow IT *Shadow IT refers to user-driven innovation caused by a lack of functionality of the IT-system. E.g. internal excel macros.* *Will the investment increase or decrease the amount of shadow IT in the company?*	New functions will decrease the amount of shadow IT 1 2 **3** 4 5 6 7	Inflexibility of IO2 will require new shadow IT 1 2 3 4 **5** 6 7

Category	Investment option 1	Investment option 2
Technical debt *This encompasses current programming of the IT-system, quality of its documentation and the thoroughness of previous programming. How will the investments affect the technical debt with regard to interfaces and other functions linked to the IT-system?*	With the implementation of IO1, some faulty code will be removed and replaced 1 *2* **3** 4 5 6 7	With the implementation of IO2, some faulty code will be removed and replaced 1 2 **3** 4 5 6 7
Governance using the IT-system *How will the investment influence the company's ability to control through IT? Possible adaptability to organizational change with the help of the IT-system.*	The company will be able to govern more efficiently with the assistance of IO1 compared with today 1 2 **3** 4 5 6 7	Catastrophic for the company's ability to handle changes to their organization due to the corporate group. Controlled by the template 1 2 3 4 5 6 **7**
Autonomy *What lock-ins will the investment option cause on the organizations ability to perform as an autonomous unit?*	No change in the company's ability to perform as an autonomous unit 1 2 3 **4** 5 6 7	Forced into a template that will cause severe consequences in the case of changes to the corporate group. Dependent on another company for competence 1 2 3 4 5 **6** 7

3. Final questions

Are these ten categories enough to evaluate the effect on technology debt caused by these two investment options? Why/Why not?

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Other additions or thoughts?

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Questionnaire regarding technology debt in Company AB

1. Background

Name: *Interviewee 8*

Email address: *Interviewee.8@company.se*

Age: *67 years*
How many years have you worked at Company AB? *22 years*
At current position? *5 years*

Before starting at Company AB, what was your experience within the field of IT-systems?
(S)he has been working with IT-systems and IT for about 40-45 years

Professional title: *System manager/Project manager*

On a day-to-day basis, how do you come in contact with the IT-systems at the company?
(S)he has the responsibility for a couple of systems. (S)he *works with the maintenance and development of this systems on a day-to-day basis*

What is your general opinion regarding the two alternative investment options?
IO1 is the better option. (S)he has experience from IO2 from previous projects, this has given a negative image of IO2

2. Identification and measurement of technology debt

Technology debt is defined as: “Accumulated obligation owned by current CIO (debtor) to future CIO (creditor), where previous decisions limit prospective decisions (Magnusson and Bygstad, 2014)”.
How will company AB’s technology debt be affected, using the following ten categories as a framework? You are also requested to evaluate the impact the investment options have on the technology debt on a scale 1-7, where 7 implies a greatly increased technology debt, 4 equals no change in debt, 1 implies a greatly decreased technology debt.

Category	Investment option 1 (IO1)	Investment option 2 (IO2)
Ideology among **IT-staff** *The IT-staff possess certain preferences/bias regarding choice of software or system etc. Will a future CIO be forced to make a decision based on ideology instead of a rational decision?*	No change from today 1 2 3 **4** 5 6 7	More difficult for a future decision-maker to make a rational decision due to a stronger ideology among the IT-staff 1 2 3 4 5 **6** 7
Competence among **IT-staff** *IT-staff tend to possess specific IT-competence. Will the investment cause a concentration of competence and/or influence future CIO’s recruitment process?*	Less concentration in competence among the IT-staff, similar to current staff 1 2 **3** 4 5 6 7	Stronger concentration in competence among the IT-staff, similar to current staff 1 2 3 4 **5** 6 7
Working environment for **users** of the IT-systems *How will the working environment/atmosphere be affected by the investment? For example impact on user’s ability to influence the IT-system.*	The working environment will be better than today due to the IT-users ability to impact the IT-system 1 2 **3** 4 5 6 7	Due to the complexity with IO2, the working environment will be worse than before 1 2 3 4 5 **6** 7

Category	Investment option 1	Investment option 2
User satisfaction among employees who use IT *Usability of the system, e.g. simplicity of the user interface and so on. How do you think that the investment will affect the usage of the IT-system?*	There is a familiarity with IO1 that will increase the user satisfaction 1 2 **3** 4 5 6 7	Due to the template that is being enforced, there is a considerable lock-in that will decrease the user satisfaction 1 2 3 4 5 **6** 7
Reputation of the investment among **users** of the IT-system *This involves perception of the investment option regarding; reliability, requirements, and service-level. Is there a reputation that affects the willingness to use the investment option?*	The reputation does not affect the willingness to use IO1 1 2 3 **4** 5 6 7	The reputation does not affect the willingness to use IO2 1 2 3 **4** 5 6 7
System-infrastructure *Cooperation between the IT-system and the various interfaces and modules. How will time, cost and knowledge affect development of internal interfaces and modules?*	Since IO1 is a professional IT-system, there will be no change compared with today 1 2 3 **4** 5 6 7	Since IO2 is a professional IT-system, there will be no change compared with today 1 2 3 **4** 5 6 7
Shadow IT *Shadow IT refers to user-driven innovation caused by a lack of functionality of the IT-system. E.g. internal excel macros.* *Will the investment increase or decrease the amount of shadow IT in the company?*	IO1 will contain the same functions as the current IT-system does 1 2 3 **4** 5 6 7	IO2 will contain the same functions as the current IT-system does 1 2 3 **4** 5 6 7

Category	Investment option 1	Investment option 2
Technical debt *This encompasses current programming of the IT-system, quality of its documentation and the thoroughness of previous programming. How will the investments affect the technical debt with regard to interfaces and other functions linked to the IT-system?*	The amount of faulty code will not change compared with today 1 2 3 **4** 5 6 7	With the implementation of IO2, some faulty code will be removed and replaced 1 2 **3** 4 5 6 7
Governance using the IT-system *How will the investment influence the company's ability to control through IT? Possible adaptability to organizational change with the help of the IT-system.*	The ability to govern will be marginally increased due to better responsiveness in the system 1 2 3 **4** 5 6 7	Due to the template, Company AB will be able to govern its organization better. Mainly due to the standardization within the corporate structure 1 2 **3** 4 5 6 7
Autonomy *What lock-ins will the investment option cause on the organizations ability to perform as an autonomous unit?*	With the implementation of IO1 the company would be perceived as more independent, thus acting more independently 1 **2** 3 4 5 6 7	Company AB will face a huge lock-in if they implement IO2, mainly due to the template that is being enforced by the mother company 1 2 3 4 **5** 6 7

3. Final questions

Are these ten categories enough to evaluate the effect on technology debt caused by these two investment options? Why/Why not?

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Other additions or thoughts?

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Questionnaire regarding technology debt in Company AB

1. Background

Name: *Interviewee 9*

Email address: *Interviewee.9@company.se*

Age: *64 years*
How many years have you worked at Company AB? *35 years*
At current position? *10 years*

Before starting at Company AB, what was your experience within the field of IT-systems?
(S)he has contact with machines on an operational level. (S)he has previously worked a lot with IBM-software.

Professional title: *System manager/Project manager*

On a day-to-day basis, how do you come in contact with the IT-systems at the company?
(S)he works with cooperation between systems and daily backup policies

What is your general opinion regarding the two alternative investment options?
(S)he thinks that there is nothing positive to say about IO2. No comment on IO1

2. Identification and measurement of technology debt

Technology debt is defined as: “Accumulated obligation owned by current CIO (debtor) to future CIO (creditor), where previous decisions limit prospective decisions (Magnusson and Bygstad, 2014)”.
How will company AB’s technology debt be affected, using the following ten categories as a framework? You are also requested to evaluate the impact the investment options have on the technology debt on a scale 1-7, where 7 implies a greatly increased technology debt, 4 equals no change in debt, 1 implies a greatly decreased technology debt.

Category	Investment option 1 (IO1)	Investment option 2 (IO2)
Ideology among **IT-staff** *The IT-staff possess certain preferences/bias regarding choice of software or system etc. Will a future CIO be forced to make a decision based on ideology instead of a rational decision?*	Marginal change compared to current state 1 2 3 **4** 5 6 7	A totally changed ideology, closer connection to the other companies in the corporate group 1 2 3 4 5 **6** 7
Competence among **IT-staff** *IT-staff tend to possess specific IT-competence. Will the investment cause a concentration of competence and/or influence future CIO’s recruitment process?*	The staff already possess suitable skills 1 2 3 4 **5** 6 7	Would require drastic changes in recruitment and new knowledge would have to be obtained 1 2 3 4 5 6 **7**
Working environment for **users** of the IT-systems *How will the working environment/atmosphere be affected by the investment? For example impact on user’s ability to influence the IT-system.*	Unchanged, the company is afraid to make changes today. 1 2 3 **4** 5 6 7	Everything will be decided above the company’s head 1 2 3 4 5 6 **7**

Category	Investment option 1	Investment option 2
User satisfaction among employees who use IT *Usability of the system, e.g. simplicity of the user interface and so on. How do you think that the investment will affect the usage of the IT-system?*	Marginal difference compared with today 1 2 3 4 **5** 6 7	Users will be less satisfied due to the long process to make changes 1 2 3 4 5 **6** 7
Reputation of the investment among **users** of the IT-system *This involves perception of the investment option regarding; reliability, requirements, and service-level. Is there a reputation that affects the willingness to use the investment option?*	No reputation that will affect the willingness to use the system 1 2 3 **4** 5 6 7	Has a bad reputation 1 2 3 4 **5** 6 7
System-infrastructure *Cooperation between the IT-system and the various interfaces and modules. How will time, cost and knowledge affect development of internal interfaces and modules?*	Interface will be easily changed by their own staff as long as they are in control 1 2 3 4 **5** 6 7	Less control and will not work seamlessly with other systems 1 2 3 4 5 **6** 7
Shadow IT *Shadow IT refers to user-driven innovation caused by a lack of functionality of the IT-system. E.g. internal excel macros.* *Will the investment increase or decrease the amount of shadow IT in the company?*	Both options will increase the amount of shadow IT 1 2 3 4 **5** 6 7	Both options will increase the amount of shadow IT 1 2 3 4 **5** 6 7

Category	Investment option 1	Investment option 2
Technical debt *This encompasses current programming of the IT-system, quality of its documentation and the thoroughness of previous programming. How will the investments affect the technical debt with regard to interfaces and other functions linked to the IT-system?*	No change compared with today 1 2 3 **4** 5 6 7	No change compared with today 1 2 3 **4** 5 6 7
Governance using the IT-system *How will the investment influence the company's ability to control through IT? Possible adaptability to organizational change with the help of the IT-system.*	Easily adaptable as they control the system themselves 1 2 3 4 **5** 6 7	Opposite of IO1, almost no control. Hard to make adjustments 1 2 3 4 5 **6** 7
Autonomy *What lock-ins will the investment option cause on the organizations ability to perform as an autonomous unit?*	Marginal difference compared with today 1 2 3 4 **5** 6 7	Company AB will face a huge lock-in if they implement IO2, mainly due to the template that is being enforced by the mother company 1 2 3 4 5 **6** 7

3. Final questions

Are these ten categories enough to evaluate the effect on technology debt caused by these two investment options? Why/Why not?

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Other additions or thoughts?

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8.2. Appendix B (Tables and radar-charts)

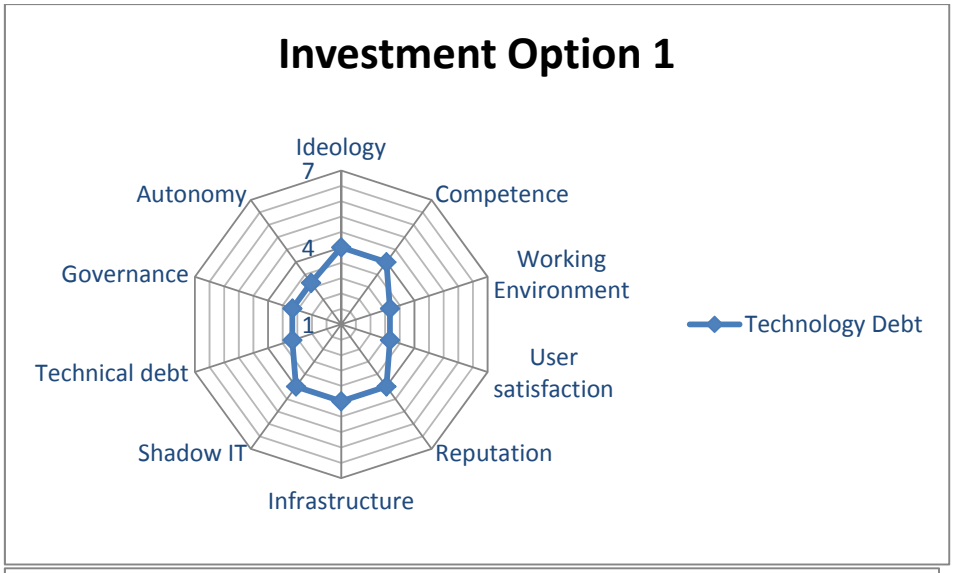
Tables and radar-charts with data from the interviews

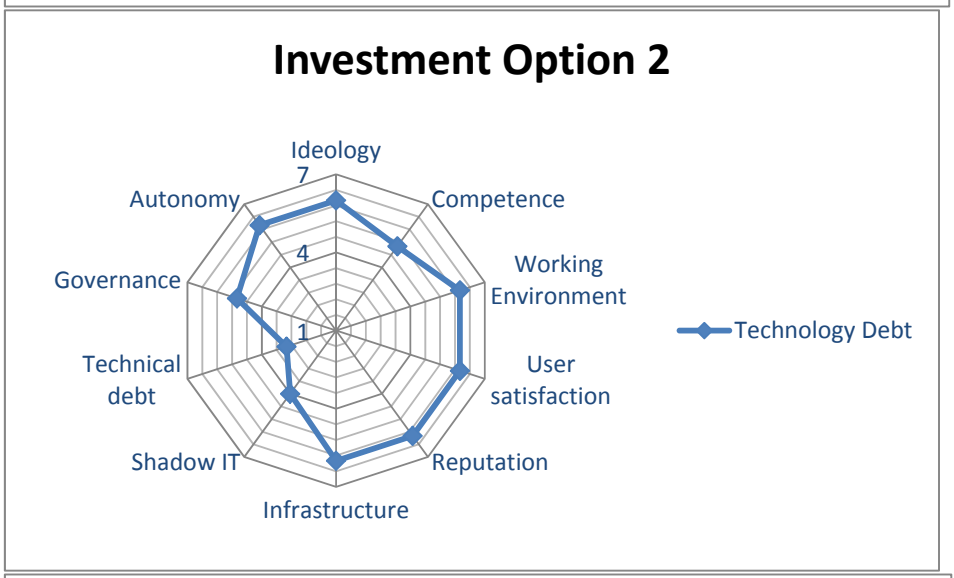
The valuation: Investment Option 1

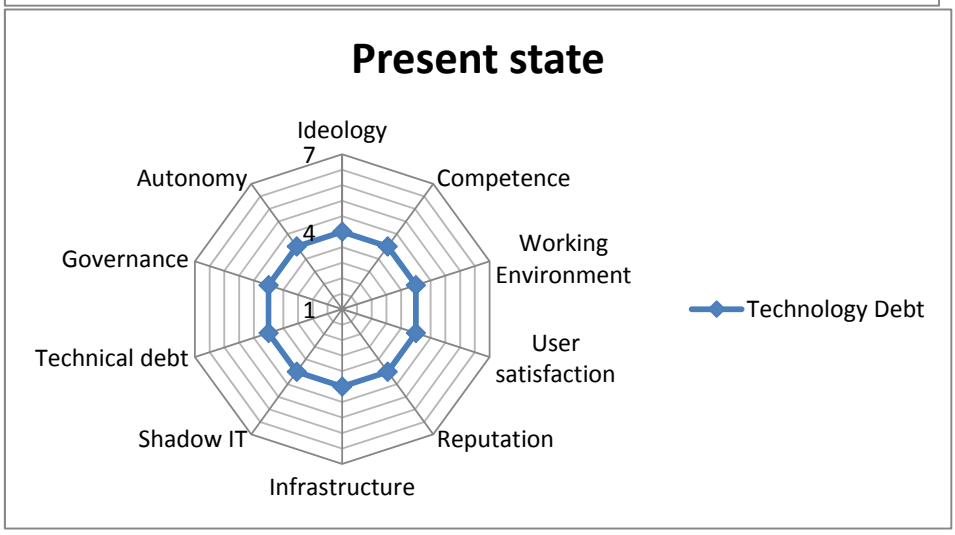
Interview(IV):	IV 1	IV 2	IV 3	IV 4	IV 5	IV 6	IV 7	IV 8	IV 9	Total (max=63)	Mean	Median	Max	Min
Ideology	4	5	4	4	4	4	2	4	4	35	3,89	4	5	2
Competence	4	4	4	4	4	3	6	3	5	37	4,11	4	6	3
Working Environment	5	3	3	2	4	3	3	3	4	30	3,33	3	5	2
User satisfaction	5	4	3	2	2	2	4	3	5	30	3,33	3	5	2
Reputation	4	3	3	5	3	2	4	4	4	32	3,56	4	5	2
Infrastructure	4	6	3	3	4	5	4	4	5	38	4,22	4	6	3
Shadow IT	4	3	4	4	3	3	3	4	5	33	3,67	4	5	3
Technical debt	2	3	3	4	3	2	3	4	4	28	3,11	3	4	2
Governance	2	2	3	2	4	2	3	4	5	27	3,00	3	5	2
Autonomy	3	3	2	4	4	3	4	2	5	30	3,33	3	5	2
Total (max=70)	37	36	32	34	35	29	36	35	46	**320**	35,56	**35**	46	29

The valuation: Investment Option 2

Interview(IV):	IV 1	IV 2	IV 3	IV 4	IV 5	IV 6	IV 7	IV 8	IV 9	Total (max=63)	Mean	Median	Max	Min
Ideology	4	4	5	5	7	6	7	6	6	50	5,56	6	7	4
Competence	4	5	4	3	6	5	3	5	7	42	4,67	5	7	3
Working Environment	7	6	6	3	5	7	7	6	7	54	6,00	6	7	3
User satisfaction	6	6	6	2	6	7	5	6	6	50	5,56	6	7	2
Reputation	7	7	6	5	5	7	6	4	5	52	5,78	6	7	4
Infrastructure	7	6	6	6	7	6	7	4	6	55	6,11	6	7	4
Shadow IT	4	3	6	4	2	7	5	4	5	40	4,44	4	7	2
Technical debt	2	3	3	4	2	2	3	3	4	26	2,89	3	4	2
Governance	7	2	5	2	4	7	7	3	6	43	4,78	5	7	2
Autonomy	6	6	6	4	6	7	6	5	6	52	5,78	6	7	4
Total (max=70)	54	48	53	38	50	61	56	46	58	**464**	51,56	**53**	61	38


Investment Option 1
Ideology
7
Competence
Working Environment
User satisfaction
Reputation
Infrastructure
Shadow IT
Technical debt
Governance
Autonomy
4
1
Technology Debt


Investment Option 2
Ideology
7
Competence
Working Environment
User satisfaction
Reputation
Infrastructure
Shadow IT
Technical debt
Governance
Autonomy
4
1
Technology Debt


Present state
Ideology
7
Competence
Working Environment
User satisfaction
Reputation
Infrastructure
Shadow IT
Technical debt
Governance
Autonomy
4
1
Technology Debt