The Added Value of Enterprise Architecture[1]

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The Added Value of Enterprise Architecture

THESIS

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in

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"The important thing is not to stop questioning." *Albert Einstein (1879 - 1955)*

Preface

PERFORMING this Master Thesis has truly been a valuable journey, which started at the flexible workplace of the practices P20 and P30 at Capgemini. At this workplace, many employees drop by and I enjoyed the conversations with employees who shared their work experience. These conversations triggered my interest in assessing the value of architecture. This was stimulated by attending a one week architecture course at Capgemini University Les Fontaines in France. As a student, I felt blessed being given the opportunity for attending such an intriguing course. My journey continued along meetings with interesting people, from whom I got to know Raymond Slot, who shared his inspiring views. He gave me the possibility to perform this research at FinCom. This enabled me to fulfill one of my aspirations: having theory of architecture meet practice. Therefore, I am very thankful to Raymond Slot, who I got to know as an excellent professional from whom I gained enormous knowledge.

I would like to thank Jan Dietz for his support during the research and his remarks. He definitely made me push myself to a higher level, for which I am thankful. In addition, I would like to thank Ralph Feenstra who, even though we had brief contact, gave me confidence and encouraged me by constructive criticism.

I would also like to thank Max Stahlecker, who helped me a lot in establishing the end product of this thesis. The long evenings working at FinCom were rather enjoyable than obliged, while still remaining productive. Furthermore, I am very thankful to Jos Berière who gave thought-provoking remarks and improvements through the thesis. I would also like to thank Stijn de Reede, friend and colleague at Capgemini. Our mutual encouragement and support in completing the thesis has led to repetitive surprises of the security staff, who found us working on late evenings in the desolated Capgemini building. Another group of people I am thankful for are the employees at FinCom; Jos, Wouter and Ton.

And, last but not least, I would like to thank my parents and sister Julie for their unrelenting support and their outstanding balance between pushing and pulling me through the thesis.

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Contents

List of Tables

List of Figures

Abstract

APPLYING architecture implies that it provides added value across an enterprise. Although widely adopted, this claim has only been scarcely investigated, not to mention quantified.

This document describes the results of a case study to quantify the effects of applying Enterprise Architecture within a financial institution called FinCom. For confidential information reasons, the name of this company is fictive. The thesis attempts to capture several factors at project level with respect to the application of Enterprise Architecture and its subsequent financial benefits. The study analyzed 40 projects, with regard to time and budget overrun. In order to collect these data, a total of 35 business, enterprise and domain architects were interviewed on their experience with these projects. Among factors taken into account were architecture type, project compliance to architecture and experience of the architect. Consequently, these factors are recorded in hypotheses that relate to the budget and time figures of the project. These hypotheses are incorporated in the 'Architecture Effectiveness Model' and statistically tested with the acquired data. This led to more than 12.000 calculations to show the subsequent benefits of Enterprise Architecture.

Chapter 1.

Introduction

> "SOFTWARE can easily rate among the most poorly constructed, unreliable and least maintainable technological artifacts ever invented by man – with perhaps the exception of Icarus's wings" (Strassmann, 1996)

In order to certainly beat Icarus in the ability of constructing technological artifacts, new perceptions on developing software have evolved during the last years. However, concluding from previous researches, there does not seem to be a relation between IT investments and economic advantages. Strassman states:

> "It is safe to say so far nobody has produced any evidence to support the popular myth that spending more on information technologies will boost economic performance" (Strassmann, 1997)

As a reason for this peculiar fact, Strassman explains that IT decisions are mostly based on short term expectations. Therefore new insights have arisen that focus on long term IT decisions.

One of these insights is the belief that the information technology of an enterprise must be developed according to principles laid out in order to fulfill its mission. Subsequently, to ensure sufficient business IT alignment and fit, Enterprise Architecture has been developed as a professional area of interest in order to form the 'key to success'.

Attention must be paid to the use of terms such as 'business IT alignment', 'architecture' and more. These terms are relatively novel and some terms originate from other professions or cultures (such as 'architecture' when used in the context of Roman Architecture). When a term is introduced in this thesis and the term is susceptible to misinterpretation, we will provide its definition as used in this thesis. The Glossary contains a list of these definitions.

1.1. What is Enterprise Architecture?

Before explaining the term Enterprise Architecture (EA), we first elaborate the term 'enterprise'. Enterprises pursue a certain set of goals, set by its management. An enterprise can differ from a single person's business to a multinational operating globally. The only criterium that classifies whether a set of humans working together can be considered as a system, is whether these people strive for a certain 'set of goals'. As a definition of an enterprise we use the following:

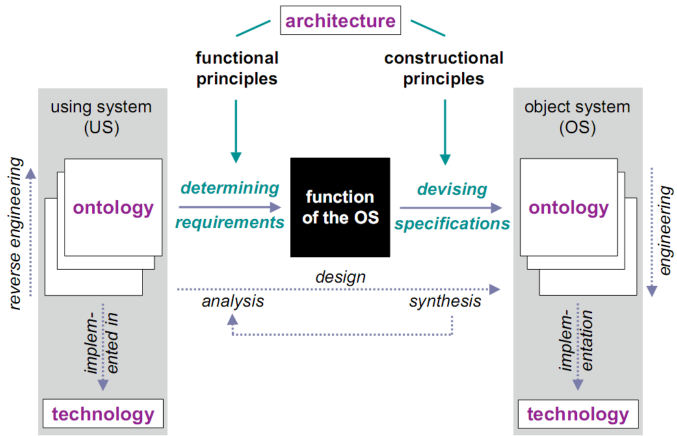

Figure 1.1: *The system development process (Dietz, 2006)*

> "A purposeful or industrial undertaking." (Princeton University, 2008)

In this sense, an enterprise can be a whole corporation, division of a corporation, a government organization or a single department. The term 'enterprise' can also be substituted by firm, organization, company or any other synonymous term.

Now that we have defined the first part of the term EA, we can move on to the next part. EA is considered as something that concerns the enterprise as a whole. If we look at existing definitions of EA, we see that we can split them into two types: descriptive and prescriptive.

A descriptive definition concerns the construction of a system. The descriptive notion of architecture does not apply to a set of systems, but is more specifically set up for one system. An example of such definition is:

> "The fundamental organization of a system embodied in its components, their relationships to each other and to the environment and the principles guiding its design and evolution." (IEEE)

Or:

> "The capture of all behavior that goes on in an organization, the data that is processed, who does what, where everything is, and why everything is done." (Harrison and Varveris, 2004)

The prescriptive notion, however, takes this notion of architecture to a higher level:

> "Architecture is the normative restriction of design freedom" (Dietz and Albani, 2005; Dietz and Hoogervorst, 2007)

This definition is further illustrated by Figure 1.1.

In this figure, two systems are shown, the using system (US) and the object system (OS) . The US is the system that 'uses' the OS, that has to be designed. Both systems can have models describing their construction. On the highest level, for both systems an ontology model can be specified that describes the system in terms of its essential construction and operation Dietz (2006). The design of the OS is guided by principles that are stated in architecture. This is achieved by applying both functional principles as well as constructional principles in this process. The process starts by specifying the 'ontology' (the essence of the system) of the using system and eventually leads to, through applying functional principles, a 'black box' representation that contains the functions that need to be designed. Subsequently, the constructional principles will guide the specification of the ontology of the OS from the black box to the ontology of the OS.

Consequently, we will use the prescriptive definition because this definition enables us to view architecture not as a design, but rather as a set of principles and rules on which the design is based. This notion of architecture helps us in specifying a design according to a set of high level principles and as such limiting design freedom. Architecture provides the principles and rules that must be adhered to when the enterprise's processes and supporting information technology is constructed.

Likewise, the term 'Enterprise Architecture' is also considered to incorporate this prescriptive notion of architecture. The addition 'enterprise' in front of the term architecture, indicates that the concept of architecture considers the enterprise as a whole. As such, the terms matters the following domains of an enterprise: business, organization, information, technology (Hoogervorst, 2004a).

Hoogervorst (2004a) defines a business domain as:

> The business domain regards those enterprise activities that are purposeful and gainful (Hoogervorst, 2004a)

However, sometimes 'business' refers to the people that are authorized to regulate the processes in the enterprise that relate directly to the core tasks of the enterprise. For instance, this meaning is used in the second use of the term 'business' in:

> "The choice of the dynamic aspects of a business depicts those areas where the business wants or should be able to change and is an important aspect in its design" (van der Zijden et al., 1998).

In contrast, Princeton University (2008) defines business as:

> "The activity of providing goods and services involving financial and commercial and industrial aspects" (Princeton University, 2008)

Summarizing, in several literature documents the term 'business' is context dependent. In this thesis, the last definition given is used.

1.2. Need for Enterprise Architecture

In this section, the need for EA is gradually explained by discussing the evolution of IT in enterprises. In the early years of developing information systems, basic programming techniques sufficed the information technology needs of an enterprise. However, to deal with the complexity that is associated nowadays with designing information systems, old fashioned techniques do not suffice anymore to meet the requirements and quality goals set out. The largest software projects have staggering failure rates: the Standish Report states that nearly one third of projects are canceled prior to completion and more than half suffer from serious cost overruns (Georgas et al., 2006).

Hailpern and Tarr (2006) states that a model driven design approach is not sufficient itself. Because complexity of products has increased, shortened development cycles and heightened expectations of quality major challenges are used in all stages of the development cycle. Model driven development (MDD) has made exciting improvements, and is increasingly used on a large scale. It now is applied for enterprise-wide purposes, but it is far from a foregone conclusion that MDD will succeed where previous software-engineering approaches have failed.

Georgas et al. (2006) also recognizes these complexities and explains why the development process still needs some adjustments and refinements. Many process improving techniques such as the Capability Maturity Model have focused on the processes in software engineering (such as requirements specification, high-level software design, source code and testing information). But, despite all these efforts, a significant improvement in the software built cannot be noticed. A good process does not guarantee a good product.

Subsequently, Georgas et al. (2006) introduces the reader to the term architecture: "We believe that there is another road to improving software quality and project success rates. Software architecture is a discipline that is able to connect and integrate the various stakeholders, activities and products involved in software engineering. Software architecture also allows engineers much greater control and insight into their systems earlier in the development process and can foster early identification and avoidance of problems. As a result, architecture can help steer the project toward success rather than stumbling into failure due to a lack of understanding."

It seems that Georgas et al. (2006) applies the descriptive definition of the architecture here. This can be concluded from: "Solid architectures, at the most basic level, capture a software system's structure in terms of interconnected high-level architectural elements. These elements are components and connectors, linked to each other in specific configurations."

Georgas et al. (2006) mentions the term *software* architecture. However, according to Capgemini (2006) the term architecture needs to incorporate a broader view on enterprises. Before 1985, architecture had always been of large interest when designing systems, but later on, when applications and systems increased in number and complexity, the need for an overview and a structured approach for integration became apparent. The term gradually extended to all areas involved, initially ranging from technical infrastructure to information systems, and then towards information, processes and business (Capgemini, 2006).

In other words, uncontrolled growth of information systems and technology in the late 1990's (often as a result of decentralized decision making) resulted in information and systems landscapes becoming complex, costly and difficult to manage. Responding quickly and efficiently to adapt to new business challenges became increasingly difficult. (Capgemini, 2006)

Key symptoms demanding an effective approach for EA include:

- Drive for easier business management of new projects that offer more integration and greater flexibility
- Inflexibility of current IT systems, coupled to speed of IT delivery to reap maximum benefit of its potential
- Enable business change to be accommodated more easily without a huge corresponding increase in IT or project management effort
- More effective alignment of disparate ambitions and attitudes for existing Business and IT functions
- Too many projects not delivering expected values or aborted prematurely
- Management unsatisfied with performance of IT or unclear about targeted business benefits from IT
- Rationalize overlapping and conflicting solutions arising from mergers and acquisitions
- IT landscape comprising standard packages and tailor-made software with too many interfaces resulting in additional complexity
- Too many different and standalone systems, and not enough standardization
- Increasingly, heritage and standalone systems are interrelated and need common features. For example access, security, common data, etc
- IT operational costs are high and seemingly unmanageable (From (Capgemini, 2006)).

1.3. Problem definition

Specific literature on the tangible value of EA is hardly available. This is in contrast to the information available on the non-tangible benefits of EA. Many literature documents end up by mentioning the advantages of EA in terms of flexibility, agility, business IT alignment and more. But what does it take to successfully implement EA? Roberts (2002) states that "too many architecture groups have focused on the development of extensive standards and guidelines as an end in themselves ignoring the contributions that can be made from a process that is aligned with business objectives". Accordingly, a bottom line for the success of EA is:

> "Successful Enterprise Architecture groups develop a clear understanding of their value proposition and communicate and gain acceptance of that value within the enterprise" (Roberts, 2002)

Consequently, it is important to be able to assess the value of EA throughout the enterprise. It is especially important that senior management recognizes this value, since they are prone to make decisions based on budget figures. The problem is that little information is known on these budget figures for EA.

1.4. Research objectives

Delft University of Technology
Founded in 1842, Delft University of Technology is the oldest, largest, and most comprehensive technical university in the Netherlands. With over 13,000 students and 2,100 scientists (including 200 professors), it is an establishment of both national importance and significant international standing. Renowned for its high standard of education and research, TU Delft collaborates with other educational establishments and research institutes, both within and outside of the Netherlands. It also enjoys partnerships with governments, trade organizations, numerous consultancies, industry and small and medium sized enterprises. Today, social issues are becoming progressively complex - they require a multidisciplinary approach. TU Delft uses its expert knowledge to solve these problems. In fact, society is our most important contractor TUDelft (2008).

Capgemini
Capgemini is consultancy firm with over 83.000 employees worldwide, ranging from North America, Europe and the Asia Pacific region. Its headquarters are located in Paris, France. The mission of Capgemini is to enable transformation through innovation. Capgemini enables its clients to transform and perform through technologies. Transformation is an important issue; it is essential to meet the challenges of today's complex, rapidly evolving global economy. This transformation is an important issue since Capgemini wants to empower its clients to respond faster and more intuitively to changing market dynamics. As such, its clients become more agile and competitive through leveraging new technologies. Capgemini will lead the way by providing clients with insights and capabilities that boost their freedom to achieve superior results Capgemini (2008).

The goal of this thesis is to assess the added value of EA. The main thesis question is therefore defined as:

> What model can be used for assessing the added value of Enterprise Architecture in IT projects?

Several stakeholders are interested in the answer to this question. These stakeholders involve Delft University of Technology, Capgemini and FinCom. Each stakeholder has its own objectives. FinCom focuses on the practical answer of this question, i.e. the result that is obtained when the model is applied. For Delft University of Technology the emphasis lies on the theory of the model; its construction and realization. Capgemini as a consultancy firm is interested in the model for possible future use at client projects. Summarizing, the objectives are divided into two types: theoretical and practical objectives.

Theoretical objectives

1. **To *seek* approaches in literature that aim to assess the added value of architecture**
   This is discussed in Chapter 2.

2. **To *deliver* a model that can function as a method for assessing the added value of Architecture in general EA contexts (not only for FinCom)**
   The integrity and validity of this model is guaranteed by the following subordinate objectives:

   a) **To *establish* a method that uses a scientific approach**
      This objective is discussed in Section 3.5.

   b) **To *determine* statistical methods that can be used for data analysis**
      This is discussed in Chapter 5.

   c) **To *define* factors in projects representing project success**
      This objective defines the factors that represent the value of EA. If the value of EA is high, how does this appear in a project? The factors that are captured in order to fulfill this objective are discussed in Chapter 3.

   d) **To *define* factors in projects influencing the project success**
      Among these factors are both factors related to architecture as well as non-architecture factors. Some factors are directly related to questions in a questionnaire that is used. The questionnaire has been obtained externally and is out of scope for the research. These factors are discussed in Chapter 7.2.

Practical objectives

1. **To *deliver* a model that can function as a method for assessing the added value of Architecture at FinCom**
   This objective is discussed in Section 9.2.

2. **To *produce* convincing arguments for Enterprise Architecture investments**

These arguments are derived from the findings that result from the application of the model.

a) **To *assess* the added value of Enterprise Architecture at FinCom in quantitative data**
   This are the findings that result from the application of the model. This objective is discussed in Section 8.

b) **To *pin-point* factors in IT projects of FinCom that qualitatively relate to each other**
   Other factors then architecture factors are also considered in the model. The objective is to find factors that influence project success. This objective is discussed in Section 8.

Chapter 2. Related work

In this chapter, literature is discussed that is about the value of EA. Some literature is about how EA should be implemented in enterprises in terms of its organization. It discusses several internal structures of enterprises that have proven to be effective in the field of EA and summarizes how these enterprises organized EA and its governance. However, this situation is not applicable to FinCom, as this research assumes that the governance of EA in the company is mature and efficient and this is not an objective of the research.

2.1. Intangible value of EA

Enterprises have problems implementing their strategic initiatives according to Hoogervorst (2004b): There are three important causes why these initiatives are failing:

- Strategic initiatives are focused more on what things should be implemented rather than how
- The various domains (business, information, technology) are not considered in co-operation with each other
- The (often tacitly) applied principles and rules are not consistent.

These issues provide us with high-level reasons on why there is a need for EA. EA resolves the inconsistencies described above and formulates principles in a coherent and consistent way. Once EA has been applied, it will enable enterprises to reap the benefits of EA, providing that EA is applied correctly. There is much interest on indicating these benefits of EA. An important reason for this is that an application of EA is accompanied by additional costs and efforts. Therefore an important question is what the benefits of EA are. As stated before, much literature is available on these topic. For instance,

Hoogervorst (2004a) claims that the benefits of EA can be divided in three issues:

- *Enterprise Architecture enables integration*
  This means that EA integrates the several domains that an enterprise consists of. Such a domain could be a business, information or information technology domain. Applying principles to these domains lead to better integration between the domains.

- *Enterprise Architecture enables successful change*
  Strategic plans within an enterprise are always accompanied by certain changes. A change in an enterprise influences the way in which the enterprise is constructed. Therefore, EA also needs to encompass constructional principles. Only when the need for this constructional perspective is acknowledged, EA is able to support in successfully implementing changes.

- E*nterprise Architecture enables agility.*
  Because enterprises operate in increasingly dynamic markets, they need to be able to change their business as well as the supporting IT processes. In order to achieve this, design principles help designers in constructing the enterprises in such a way that they are agile and, as such, can anticipate quickly to environment changes.

Rosser (2004) postulates that, when EA is correctly applied, the benefits of EA that are interesting for the business staff of an enterprise, fall into two main areas:

1. The direct improvements in the performance of IT itself (business is looking for lower overall costs from IT)
2. The improved enterprise business performance achieved because IT enables the effective pursuit of the business strategy.

Rijsenbrij and Delen (2003) further elaborates on these benefits and describes where they will lead to in practice. According to them, EA:

- defines structure and provides overlook
- supports decision making and reduces risks
- ensures that the targets of an enterprise are met and takes care of its business IT alignment
- foresees in guidelines for development and outsourcing
- uniforms the application of IT
- assures readiness for future IT developments
- supports business transformations and migration planning
- simplifies the use of of-the-shelf-software
- aids integration of systems
- stimulates the reuse of proven technology
- simplifies the integration of partners like service providers (Rijsenbrij and Delen, 2003).

Much more literature can be found on this topic, however, they all seem to originate from the above three basis principles specified by Hoogervorst (2004a).

2.2. Effectiveness of EA

Yet, not much literature is available on how to achieve effectiveness of EA. It is still highly uncertain (in some businesses) and little research evidence establishes the (tangible) benefits of EA or helps firms assess their EA (Kamogawa and Okada, 2005). Kamogawa and Okada (2005) introduces a framework that functions as a starting point for assessing the value of EA, by addressing the success factors in an EA implementation. They derive, from research done by Schekkerman (2005) and, according to a survey, the following assumptions regarding the implementation of EA can be made:

- Methodologies and tools for EA will be effective for developing and maintaining EA
- The more Governance that is established and penetrated into the IT community, including the IT Department, the more beneficial EA will be to EA development and maintenance
- If the top management of a firm improves cognition with regard to EA, the effect and benefits of EA will be higher.

These results function as the basis for addressing success factors of EA. The above statement mentions the term Governance. Governance is the process of utilizing, maintaining and improving EA. From the assumptions above, the following influential factors on EA can be derived (Kamogawa and Okada, 2005):

- Enterprise Architecture Development Power (EADP)
- Enterprise Architecture Cognition (EAC)
- Enterprise Architecture with Governance (EAWG).

These factors are crucial for the correct and significant application of EA. EADP shows that the roles and skills of those involved with applying EA are a key success factor. EAC means commitment and involvement of the senior management at board level in the application of EA. This includes the CEO and CIO line of business managers. EAWG is about establishing the importance of governance, which is needed in order to maintain the EA initiative. It is necessary to adapt EA to changes in business environment and this is an ongoing process that needs governance. Because of this ongoing process, it is not possible to successfully implement EA without governance.

Subsequently, Kamogawa and Okada (2005) denote four business values which can be derived from Weill (2004):

1. Business process excellence. The business operations will need to be cost-conscious, efficient and productive
2. Customer Oriented. Extraordinary customer service, responsiveness based on deep customer information and knowledge

3. Innovation. Being the first in the market with innovative products and services, support for rapid Research and Design (R&D) commercialization processes

4. Strategic Adaptability. The ability to rapidly penetrate new markets and being able to quickly respond to competitor initiatives.

Next, these business values are combined with the influential factors of EA in order to obtain the success factors, resulting in Table 2.1.

Table 2.1: *Business values versus influential factors (Kamogawa and Okada, 2005)*

	Influential factors		
Business values	**EA development Power**	**Governance**	**EA Cognition**
Business Process Excellence	Architect dependent	Management process	
Customer Oriented		Principle	
Innovation	Architect dependent	Investment priority	
Strategic Adaptability			Top management

The contents of Table 2.1 show us what the critical success factors are in an EA approach. It reveals that the skills of architects are a matter of major concern. Another conclusion is that when governance on EA is applied correctly, it will lead to cost effective and productive business processes. Accordingly, focusing on customer orientation is achieved by governing principles that represent the customer orientation. In addition to the guiding principles, prioritizing IT investments will enhance and simplify the process of offering new products and services and, in turn, focus on innovation. Finally, top management must recognize EA as making it possible to be strategic adaptive and compete with the best competitors.

2.3. Tangible value of EA

However, the literature mentioned to this point does not discuss techniques for measuring the (tangible) value of EA. Guptill et al. (1998) discusses the possibilities of assessing the financial consequences of EA. It has become clear that EA does not fit in the traditional Return On Investment (ROI) model, since there are a lot of intangible assets involved with EA. A better way to effectively and efficiently manage IT organization (based on costs) is to combine the Total Cost of Ownership (TCO) with the Return on IT (ROIT) method of Gartner. Yet, this does not concern the value assessment of EA, but of IT instead. However, we find it interesting to mention it here. TCO is a technique that makes a difference between two types of costs: direct costs and indirect costs. Direct costs are explicit expenditures such as buying hardware or software, help desk support or development. Indirect costs are costs hidden in the organization, such as lost productivity due to a server breakdown.

The ROIT method consists of two elements, from which the first is "situational awareness". This entails that the management of an enterprise must have a clear understanding on the current situation in the sense that it is fully aware of the processes in the enterprise. Additionally, the management must know what the IT situation is within the enterprise. When these conditions are met, the value of so-called Business Requirement Units can be addressed:

- Risk/availability
- Complexity of application
- Service/support (Guptill et al., 1998).

Each of these requirements contains a set of defined states (according to the enterprise) and each is accompanied with a weight factor. By multiplying these weight factors with the belonging states, a value of the technology in the organization is established.

The other element in ROIT entails the organization metrics. These metrics represent the values of criteria of the stakeholders involved. Such criteria could be functionality, availability, customer support, performance, effectiveness or expertise. The values of these metrics can be established by surveys. In this way, the intangible assets are covered.

However, this method also does not involve measuring the value of EA on the enterprise. Instead, it focuses on the value of IT. A drawback of this method is that it involves estimating the weight factors, so that there is still considerable uncertainty involved.

Chapter 3.

Research approach

Regarding this chapter, the approach for the research is discussed. The reasons for choosing this approach are elaborated and subsequently the quality and risks are discussed.

3.1. Introduction

This thesis aims to quantify the added value of EA. An attempt will be made to make the application of EA tangible in such a way that enterprises will see EA as a business enabler rather than as a costly exercise without clear added value. It is crucial that we define the 'added 'value of EA' beforehand:

> "The added value of EA is defined as the value of the *result* of EA that is achieved compared to the value of the result that would have been achieved if EA was *not* applied"

This definition implies that we have to isolate the result of EA on projects from other factors that influence the project, in order to obtain this 'specific' value.

In order to examine the levels on which architecture operates, consider the generic model for information management as depicted in Figure 3.1. This model is derived from the basic model of Henderson and Venkatraman (1992) and an 'information and communication' column is added as well as a 'structure row'. These both represent the areas for which architecture defines the concepts and tools. Consequently, architecture links business to technology as well as strategy to operation.

> According to Slot (2008), the value of EA can be investigated by looking at the five steps of a transformation process:

1. Develop a vision of the new situation
2. Develop a strategy to achieve the new situation
3. Describe the new situation
4. Describe a migration path towards the new situation
5. Implement the new situation.

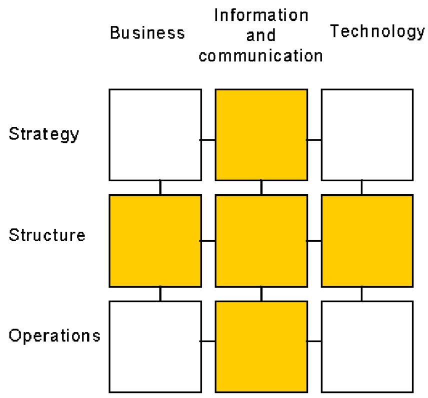

Figure 3.1: *Generic model for information management (Maes, 1999)*

These steps can also be performed without considering the use of EA. However, EA is seen as a concept that *improves the quality* of these steps. This leads to the following statement:

> "Enterprise Architecture is a management instrument to improve the quality of the Business and IT transformation process" (Slot, 2008)

Consequently, Slot (2008) defines the role of EA in these five steps:

- *A supportive role during the development of the vision and the strategy.* Architecture may highlight new (technical) possibilities, to be included in the vision and strategy
- *A leading role during the description of the new situation.* Architecture will structure and describe the vision into more detail
- *A cooperative role during the description of the migration path.* Definition of the migration path is done cooperatively between line management, program management and architecture
- *A controlling role during the implementation.* Architecture will restrict the choices of the implementation in order to improve the alignment between vision and implementation.

  Consequently, the value of EA in the business IT transformation process can be depicted by Figure 3.2.

From this picture, the levels on which the value of EA can be examined can be derived. Consequently, the value of architecture appears on three levels:

- Strategic level

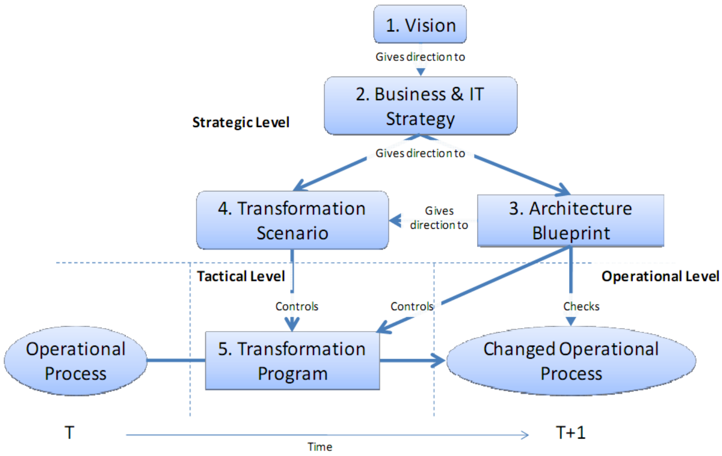

Figure 3.2: *Transformation from vision to operation (Slot, 2008)*

- Tactical level
- Operational level.

This research focuses on establishing the value of architecture on *operational level.* This approach is considered as the most accessible and convincing, since this level enables us to use a short term approach that processes project data, rather than ending up with complicated and long term strategic plans.

To assess the added value of EA for IT projects the results of finished projects are compared with the use of EA in these projects. The researched projects are restricted to those that are performed within a large financial company. Because some information in this thesis contains business sensitive topics the name of this company is fictitious. We shall call the company FinCom from here on.

In order to obtain the project data two distinct project records are needed: *input factors* and *output factors*. Input factors are the factors in a project which values distinguish the project from other projects (experience of the project team, level of technological complexity, etc). The impact of architecture on a project is difficult to examine if other non-architecture related factors influence the project. Therefore we will need to capture both architecture oriented factors and non-architecture factors in the input factors. The set of analyzed projects differs in the use of architecture. Some projects were executed in strict alignment with architecture, while other projects had no architecture influence at all. It is assumed that the quality of project architecture positively correlates with these results. . Project Architecture is the prescriptive notion of architecture that is used in a project in order to align it with the overarching EA. The EA consists of a set of rules that are described on enterprise level. All notions of architecture in FinCom are considered to be prescriptive. With 'quality of architecture' we mean whether the architecture is complete, up-to date, consistent and relevant.

To determine the values of these input factors an interview approach is used. Project stakeholders (such as architects, project managers, etc.) are interviewed. Some factors that consider the result of the project are included in this category as well. However, two special factors do not belong to this category, they belong to the output factors.

These output factors represent the project success. In order to define project success we must first answer the question what FinCom wants to achieve in executing its projects. There are several reasons for initiating the projects. Some projects are set up for reasons that relate to the core values of an enterprise, such as the offering of a new service or product. Other projects are set up for more supportive reasons such as maintenance projects, projects due to legislative changes, etc. Considering the previous we cannot define project success in terms of value that is in any way related to the long term economic profit of an enterprise. Therefore we choose for an approach that considers all the projects as tasks or jobs that need to be finished and thus a project is successful if it is finished on time and within budget. An assumption here is that, if EA has added value, it will aid in keeping the execution of projects within the planned time and budget. This entails that if a project has neither time nor budget overrun it is considered successful (the rationale for this is explained in Section 3.5). As been stated before, more factors representing project result are incorporated. However, these also belong to the category 'input factors'. Output factors remain the most important project results.

The outcome referred to here is expressed in terms of budget and time. Project quality is also considered, but since these figures cannot directly be retrieved from enterprise documents, we consider them less accurate. However, these data are collected through interviews, as explained in Section 3.2.

This research is performed in two different ways. These ways arise from the input from practice in one way and the input of theory in the other way. The two ways that can be indicated are:

- Top-down approach. Hypotheses with regard to the use of architecture are set up and, with the help of data from practice, statistical analysis will test them. This is discussed in Section on page 36

- Bottom-up approach. Factors in IT projects are assigned and statistical analysis will be used in testing these. An attempt is made to explain these relations. This approach is discussed in Section on page 39.

At the end of the research, these approaches will be combined. This will result in the delivery of one model.

This thesis is part of a larger research project, performed by Capgemini employees. It is important to note that the construction of this model takes part in a larger Research Framework that is shown in Figure 3.3.

This flow diagram shows that the construction of a model (to be discussed in the following section) is influenced by the input of the "select projects" phase and the 'gather statistical results' phase. The scope of the thesis consists of the light-blue oval.

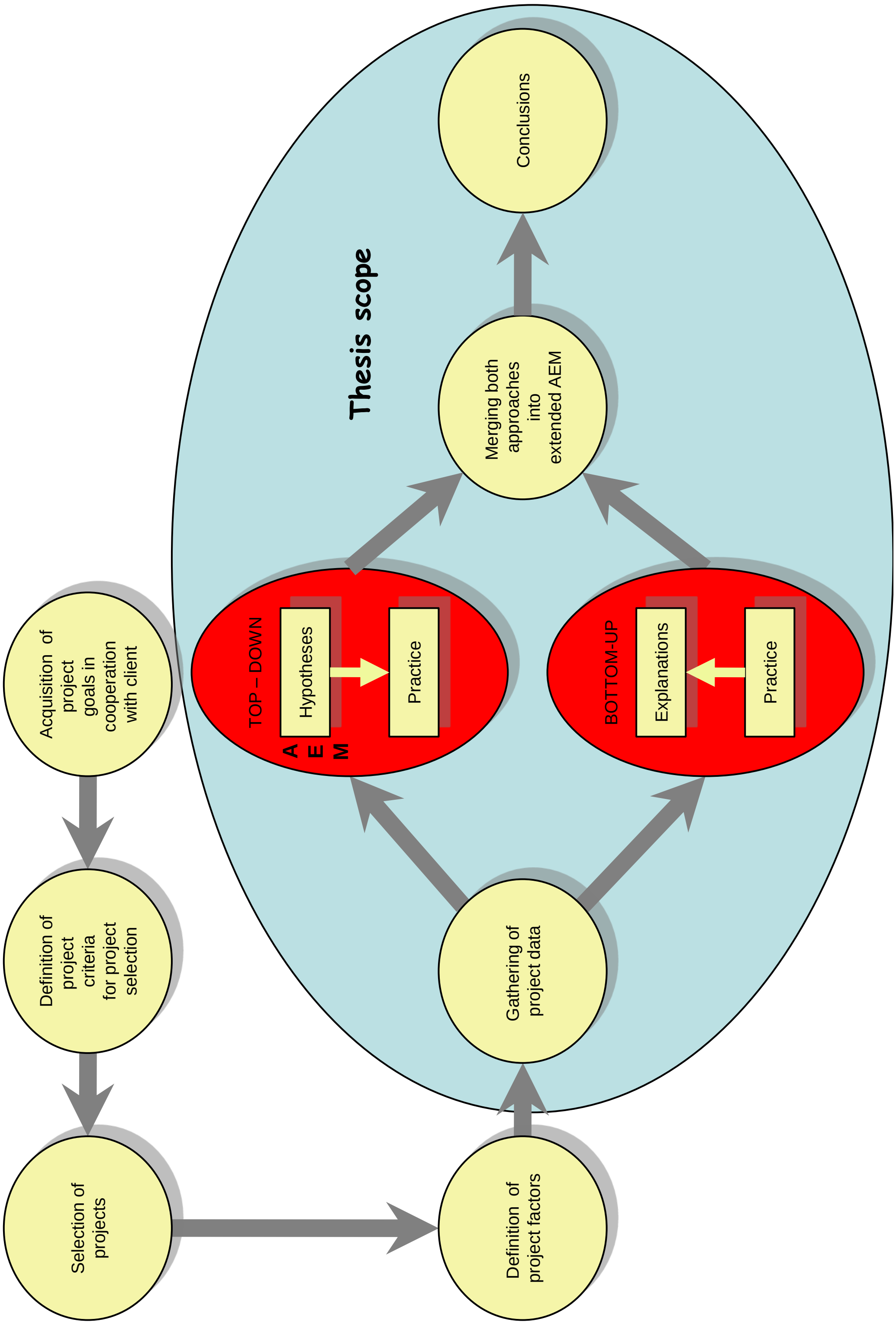

Figure 3.3: *Research Framework*

3.2. Top-down approach

This approach starts by translationing the relations that are assumed to exist in hypotheses. If we can confirm a hypothesis through statistics we are more certain that the statistical relation was not based on sheer coincidence. The Architecture Effectiveness Model (AEM) is set up in which hypotheses between question answers and project time and cost overrun are shown. As an example of how the AEM works, consider the following:

What we could, for instance, find in literature is that architecture stimulates the use of generic services (with a generic service being a service that is developed with the aspect of reuse in mind. This term seems rather vague, but a generic service is used for many things that have these characteristics within FinCom). Consider the next two statements that could be formulated as hypotheses in the AEM:

- Enterprise architecture stimulates the use of generic services
- The more generic services are used in the project, the more predictable the final project budget will be.

If we want to test these statements to practice, we try to find confirmation of them in practice, by statistically comparing data on these statements. Therefore, we need to extract data items out of projects. For this example, the following data items can be of use:

1. Level of project compliancy to enterprise architecture (this is assumed to represent the extent of use of EA)
2. Number of generic services used
3. Budget overrun at the end of the project.

Concluding from the two statements from the example, we can say that EA aids in keeping projects within budget. When formulating this conclusion, the two hypotheses are interrelated through the project variable "Number of generic services used". The project variable "level of compliancy to enterprise architecture" acts as *input factor* in this case. The "budget overrun at the end of the project" variable acts as an *output factor* here. These values are used for statistical analysis.

Schematically, the process of constructing and testing these hypotheses is shown in Figure 3.4.

Step I contains a model creation derived from two inputs. The first input is the architecture of the problem owner (FinCom). This includes architecture concepts that are specific for the problem owner. The second input is the notion of EA according to literature. This is derived from several documents existing in the field of EA. The AEM contains several hypotheses about the value of EA that are deduced from the two sides of EA located in the first step. These hypotheses represent assumptions about the effects of Project Architecture on project results. The AEM is therefore tailored to the

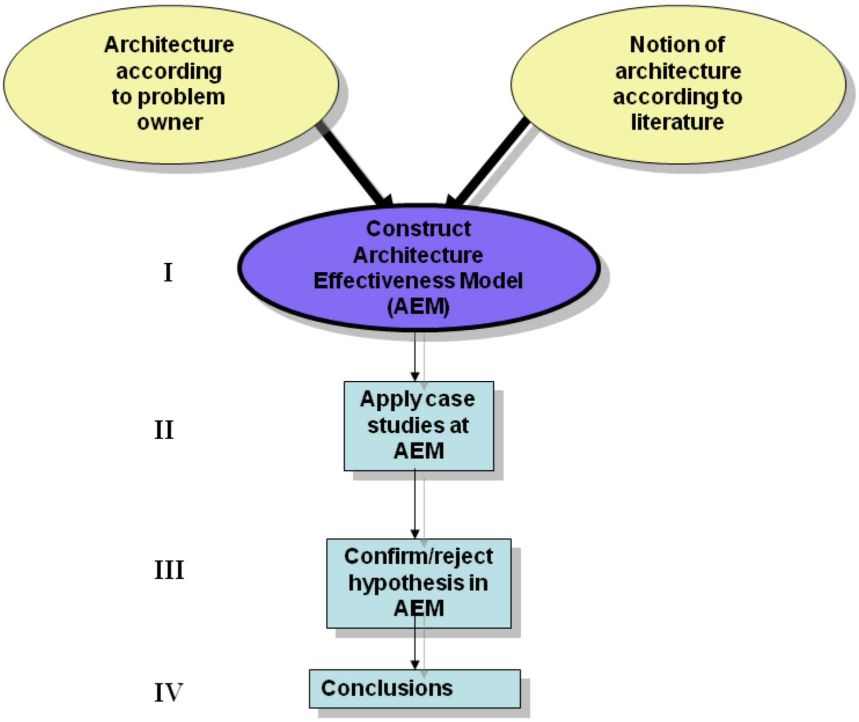

Figure 3.4: *Steps applied at the AEM*

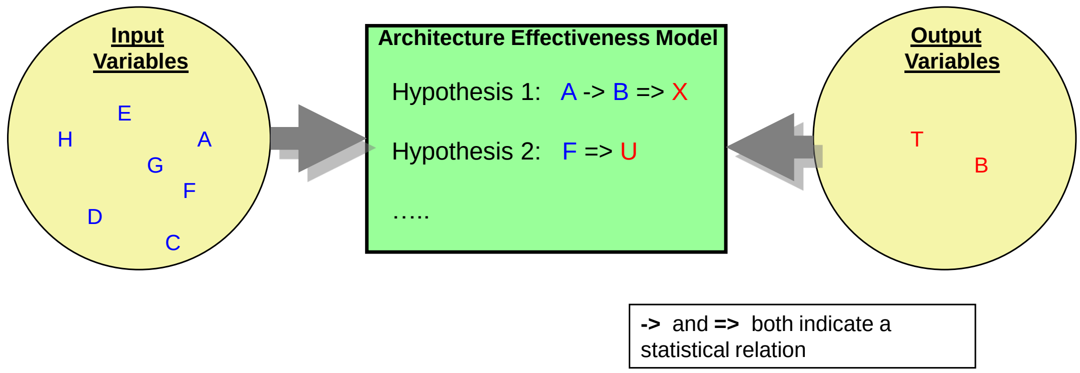

Figure 3.5: *Constructing hypotheses in the Architecture Effectiveness Model*

problem owner FinCom (later, the conclusions derived from the AEM will be presented in a generic way, such that they apply to general EA contexts).

Step II is where the theory of step I meets practice of real projects. At this point a statistical analysis on the hypotheses by using project data is performed. The projects are selected according to several project criteria. An example of such a project criterion is that the budget spent on a project must be less than a maximum set in the criterion. Another example of a project criterion is: the project should to be finished at the time the gathering of project data starts and that occurred not too long ago (aim is within 3 years).

In the AEM is documented which factors are assumed to influence each other. The values of the input factors (A to G) distinguish one project from another. The outcome of a project (that represents the success of project) is represented by the values of the output factors (T and U). Summarizing, from the start this Architecture Effectiveness Model is initiated from the notion of EA (step I). After this it is tested whether practice meets the hypotheses positioned in the AEM. Statistical analysis is then performed at the hypotheses. This step is displayed in Figure 3.5.

Step III designates the processing of the results of the statistical analysis. A check is

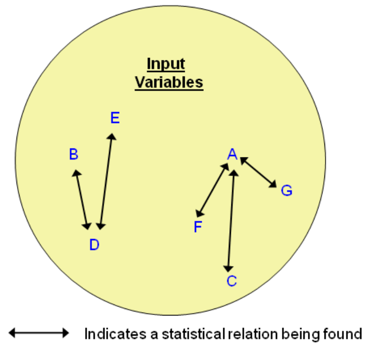

Figure 3.6: *An example of the bottom-up model*

performed whether the results correspond with the hypotheses constituted or not.

Step IV provides the conclusions. They constitute the final model of how the input factors influence project success. The model shows how EA has to be applied in such a way that the revenues of a project will increase.

3.3. Bottom-up approach

It is possible that relations between input factors that have been found are not incorporated in the AEM. Therefore, the bottom-up approach has been set up. We will use the statistical data that has been acquired. The relations between input factors will be examined by using statistical analysis. Subsequently, these relations are examined and, if possible, an explanation is given why they are related. The bottom up model contains all relations that can be explained. Note that output factors are not included in this model, since these will be covered in the top-down approach. However, we also want to incorporate these relations in the AEM, and this will eventually lead to the *extended AEM*.

3.4. Combination top-down / bottom-up

In order to produce the result of the research in one model, the extended AEM is constructed. This model combines the top-down and bottom-up approach in one model. This is the phase were the hypotheses are tested. When an hypotheses can be validated, this will be shown as such in the extended AEM. Consequently, all relations from the bottom-up model are incorporated in the extended AEM.

3.5. Justification of this approach

In order to justify the approach as mentioned in Section 3.2 and Section 3.3. Several issues that apply to a research of this nature are discussed:

Gathering of data Architecture related topics are only scarcely documented within FinCom and therefore an interview approach is chosen. These topics can include issues such as the numbers of architects meetings, the quality of the architecture, etc. Generally, these kinds of topics are difficult to obtain from existing data. More specifically, i.e. in the situation for FinCom, this information is not present in their documents.

However, financial and time data of projects can be obtained from the enterprise's business administration. Therefore, an interview approach is not necessarily for these types of data.

Research method We want to use a methodology which is widely accepted. Six Sigma is an methodology that seems to embody this requirement. A wide range of companies have found that when the Six Sigma philosophy is fully embraced, the enterprise thrives (Benbow and Kubiak, 2005). Furthermore, (Eckes, 2001) continues, "a number of major American companies have been able to achieve or maintain a leading position on their market. During the 1980's, many industrialized countries made an effort to improve procedures in their business. Various approaches were used, but only the ones that were based on a scientific method of data analysis, got the best results." Therefore, we are looking for an methodology that embraces scientific tools. According to Eckes (2001), the Six Sigma method allies scientific rigor with psychological flexibility[1]. The concept serves to provide statistical measurements of the performance of a service or product. This enables us to use a set of powerful statistical techniques on the gathered data.

In order to comprehend how Six Sigma leads to higher quality of service and products, we consider the steps of the Six Sigma methodology. We take a look at the most popular method in Six Sigma. This basic strategy of Six Sigma is indicated by the acronym DMAIC (Linderman et al., 2003; Benbow and Kubiak, 2005):

Define Definition of the scope of the project, project goals, methods of measurements towards a goal and baseline data on the current state

Measure Development of process maps and flowcharts, collecting and summarizing data

Analyze Application of statistical methods on the gathered data, drawing of conclusions and their corresponding probabilities

Improve Optimization of the process based upon the analysis using techniques like Design of Experiments (Joseph, 2005)

[1]This psychological flexibility' is an important detail here, since the data are mainly obtained through interviews.

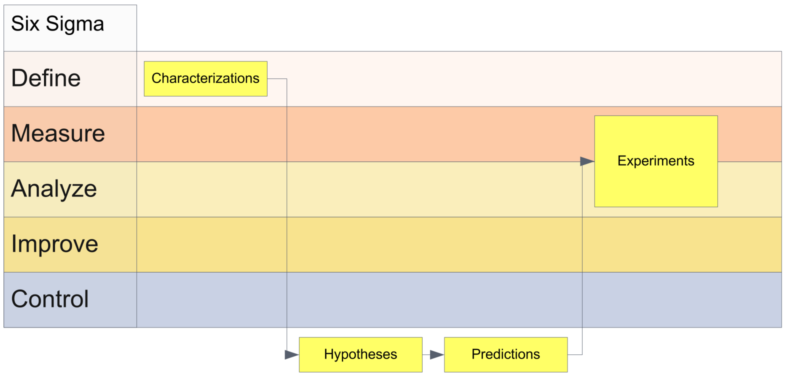

Figure 3.7: *Six Sigma combined with the scientific method*

Control To ensure that any variances are corrected before they result in defects. Set up pilot runs to establish process capability, transition to production and thereafter continuously measure the process and institute control mechanisms.

We see that (Eckes, 2001) makes an allusion to the scientific method. In order to verify whether this concept of the scientific method coincides with other concepts, we consider other definitions of the scientific method: Jevons (1877) explains the scientific method by describing its elements:

Characterizations Observe, define and measure the subject of inquiry

Hypotheses Construct a cause-and-effect relation

Predictions Try to find statements that follow directly from the hypotheses

Experiments Test the statements and find whether these are true.

In Figure 3.7 is shown how this exposition of the scientific method combines with Six Sigma.

However, not all literature sources seem to agree on this scientific element in Six Sigma. Hahn et al. (1999) claims that, apart from the analysis in Six Sigma, a theoretical foundation of Six Sigma is lacking, it has no basis for research other than "best practice" studies. Six Sigma has not been carefully defined in either the practitioner or academic literature. Hahn et al. (1999) claim that this has resulted in some confusion, since each author provides a different definition. In an attempt to develop the concepts and principles underlying Six Sigma (and thus serve as a theoretical foundation of scientific knowledge on Six Sigma), the following definition is used:

Six Sigma is an organized and systematic method for strategic process improvement and new product and service development that relies on statistical methods and the scientific method to make dramatic reductions in customer defined defect rates (Linderman et al., 2003).

In order to obtain a theoretical endorsement of Six Sigma, the theory of Six Sigma is related to goal theory (Linderman et al., 2003). Research in goal theory shows a strong relation between goal setting and performance. For example, White and Locke (1981) studied a multinational company and found goal setting correlated with performance for managers, clerical workers, and professionals. Bryan and Locke (1967) also reported that swimmers who received training in goal setting significantly improved their performance over swimmers who did not receive training. These studies illustrate the importance that goal setting has on performance in a wide range of settings. Because factors that determine the value of EA are not always easily quantifiable, we look at the following suggestion of (Linderman et al., 2003): "Sometimes quantitative data may not exist for the process, as often occurs with a new process, and setting specific quantitative goals becomes more challenging. In this situation managers should seek out alternative methods to establish explicit goals, possibly using financial or customer satisfaction data to set goals rather than relying on do-best goals". Because quantitative data directly related to EA do not exist for this case study, we will use financial data in the 'setting specific quantitative goals' for maximizing the EA performance of FinCom.

Output factors

Given the issues raised in Section 3.2, the output factors are time and budget overrun figures of each project. It is important to define time and budget overrun. Adopting from definitions from literature on the concept overrun, consider the following definition of overrun:

> "In the context of project financing, the amount of capital expenditures or funding above the original estimate to complete the project" (Campbell, 2002)

This definition specifies the budget overrun. We want to change the definition of overrun in such a way that it is *relative*; this makes the budget overrun for several projects able to compare them with each other. In other words, it makes the overrun of a project independent of the project *size* (in terms of budget or time). Therefore, the definition of budget overrun that is used in this thesis is:

$$\frac{B_a - B_p}{B_p} * 100\% \tag{3.1}$$

where

B_a = the amount of capital expenditures that was spent to complete the project
B_p = the amount of capital expenditures in the original estimate to complete the project

Consequently, the definition of time overrun is:

$$\frac{T_a - T_p}{T_p} * 100\% \tag{3.2}$$

where

T_a = the amount of time that was spent to complete the project
T_p = the amount of time expenditures in the original estimate to complete the project

In this definition both time values are expressed in days. It does not involve the amount of time that was actually spent on working on the project. In other words, if the project stopped for a while, this time is also incorporated in the time overrun.

One can argue whether it is advisable to correlate the architecture factors in a project with the budget and time overrun in a project. Another suggestion might be to compare the architecture factors to the business value of the project. This would not make much sense, since the business value of a project depends on more factors than the time and budget overrun of the project itself. This idea is also supported by Kamogawa and Okada (2005): "From the potential benefits of e-business conducted by extended enterprise, we address requirements of EA effectiveness for organizations which result from cost and time savings to bring competitive advantage and to support organizational change". Note that Kamogawa and Okada (2005) mentions "cost and time savings", which is exactly what we examine on project level in this research.

Additionally, if the architecture in a project (the Project Architecture) helps the project to be successful, then the business value does not necessarily have to be high. A project can be very successful and does not have to lead to higher enterprise profits. Therefore, we choose to compare the input factors to the time and budget overrun data, since this information is available and considered most accurate.

We do not discuss the used statistical methods here as these will be discussed in Chapter 5.

3.6. Quality

How can we guarantee high project quality? Well, if we look at the phases of the full project scope as portrayed in Figure 3.3, there are several steps in which quality is a critical factor. In this paragraph not only the blue oval is considered, but also the quality issues of the phases outside the blue oval. The most important quality issues are discussed here.

Definition of project criteria for project selection This phase has a considerable influence on the rest of the case study. It is decisive for selecting the project for the research. Therefore we must pay attention to formulating these project criteria.

Definition of input factors The phase 'definition of the input factors' is a very important. Here, the factors analyzed in the case study are determined. This includes both the input factors as output factors[2]

The quality of the input factors has several dimensions. The first is whether the input factors are the correct ones (a matter of *validity*, according to Reidenbach and Goeke (2006)). In order to determine what factors to choose, we must keep in mind that not only architecture factors decide the success of a project[3]. Other factors that influence the outcome of a project are factors such as complexity of the technical implementation, amount of stakeholders involved in the project, etc. These factors might even have more influence on the outcome of a project than architecture factors. As a consequence, it is important for this research to make a difference between several types of factors. Each group of factors belonging to the same factor type, must have the correct factors in order to accurately represent that factor type. Section 6.2.2 further elaborates on this topic.

Another dimension that must be taken into account here is whether the factors can be represented by a question in the interview. Will we obtain the desired answers for the questions (a matter of *reliability*, according to Reidenbach and Goeke (2006))? Can we expect from the interviewee that he or she is able to answer the question? Is the question specific enough to obtain a variety in its answers? Is this variety not caused by different interpretations to this question? These kind of issues are important when establishing the factors and constructing the questionnaire.

The output factors are obtained through several of the company's internal business administration systems. At the start of this research, these figures were considered reliable. However, when examining these data, they did not seem to encompass a good quality. This is further discussed in Section 8.2.1.

Formulating and refining hypotheses The next phase in the previously depicted research framework is the setting up and adjusting of hypotheses. In this phase the hypotheses are constructed and the results of the statistical analysis are processed. The quality of these hypotheses is very important. If we would find a correlation between two factors in the statistical analysis, this would not necessarily mean that there is a causal relation between these two factors. Claiming that correlation implies causation is known as a type of logical fallacy and is indicated by the Latin term *cum hoc ergo propter hoc*(Niles, 1922). There are 4 possibilities that explain circumstances of no causal relation $A \rightarrow B$ being present:

- If we find a correlation between $A \rightarrow B$, this could be caused by the fact that both A and B of the same cause. In formulas, $C \rightarrow A$ and $C \rightarrow B$
- The opposite might be true, $B \rightarrow A$
- The correlation can be based on sheer coincidence

[2]This definition can be found in the Glossary.
[3]The term 'project success' is explained in Chapter 3.1.

- A can be the cause of B, but at the same time B can be the cause of A ($A \rightarrow B$ and $B \rightarrow A$). This situation is called a self-reinforcing system (Wiener, 1961)

In conclusion, there can be no conclusion made regarding the existence or the direction of a cause-and-effect relationship only from the fact that A and B are correlated. Instead, we use the scientific approach and analyze the situation and construct a hypothesis from that situation. Then, if we find the hypothesis confirmed by statistical analysis (in such a way that the factors in the hypothesis correlate), we keep the hypothesis in the AEM. Therefore, if a correlation is found that confirms a hypothesis in Step II (see Section 3.2), we will consider that hypothesis as definitive and mark it as such in the AEM. In conclusion, the case of logical fallacy will be excluded as much as possible because we construct the hypotheses first and then apply the case studies. This is a top-down approach, rather than bottom-up and merely constructing hypothesis from plain data.

Selection of projects The phase of the selection of projects in the research framework is an one-to-one application of the project criteria. Therefore the quality issues here consider the correct selection of projects in agreement with the project criteria.

Gathering of project data This phase consists of acquiring the data through interviews and FinCom's internal business administration systems. Regarding the acquisition of data through interviews, how can we ascertain that the interviewee does not give us biased answers? When constructing the list of input factors, the factors are typically grouped into categories initially, simply to aid the comprehensiveness of those factors. If we would present the questions to the interviewee in this same order, there is a risk that the interviewee develops patterns of responses corresponding to the grouping of questions. For instance, in a research on the customer satisfaction of a manufacturer of earth-moving equipment, we want to ask questions in the categories (a) machine performance, (b) dealer service, (c) dealer parts and (d) dealer sales. Then, if a respondent has good or bad experience with a field service mechanic, he or she is prone to answer all successive questions on dealer service with high or low ratings. In order to avoid this kind of bias in the respondents' answers, we will put the randomize the order of the questions (Reidenbach and Goeke, 2006).

Performance of statistical analysis Since different types of data need corresponding statistical methods, we must make the right selection of statistical methods that are used. This will further be discussed in Chapter 5.

3.7. Risks

In this section we will discuss possible risks that may surface in the research. Following the same set-up as for the previous quality issues (Section 3.6), we will discuss the phases that are depicted in Figure 3.3.

Definition of project criteria for project selection In this phase, the projects from which statistical data are obtained are selected. A risk here is not having project selection criteria that are narrow enough. In this case the selected projects differ considerably from each other. The results of a statistical analysis would contain too many contingencies in this situation. On the other hand, it is important that the selection criteria are broadly enough defined to include a significant number of projects. In other words, there is a compromise between the number of projects that we can select and the narrowing of the selected projects' scope.

Definition of input factors Among the risks that are involved in this phase is that we do not select the correct input factors. A danger is that we do not include crucial projects factors that might strongly influence project results. Therefore, we first perform a thorough analysis for selecting the correct factors. This approach is discussed in Section 6.2.1.

There is also a risk of over-refining these factors. In this situation we will miss correlations between factors that would have been found in the case of selecting fewer factors.

Formulating and refining hypotheses The risks in this phase will be discussed in Section 5.3.

Selection of projects The phase of the selection of projects in the research framework is an one-to-one application of the project criteria. Therefore its risk issues are not as important as long as the projects are selected in compliance with the project criteria.

Gathering of project data A major risk that might occur here is that we get incorrect answers to our questions. Since the acquisition of these data has a large influence on this examination, there is a risk that we end up with wrong conclusions. Therefore it is important to ensure that the right answers to the questions are obtained. This is safeguarded by the interviewer, by offering the possibility of mutual discussion on the meaning of a question.

Another risk that can show up here is that we do not include the questions that relate most to the outcome of the projects. In other words, we did not incorporate the project factors that have a high influence on project outcomes. Given this situation, we will end up with conclusions that encompass much less refinement compared to the situation that the correct factors are incorporated in the research.

Performance of statistical analysis A risk here is that we might find relations that are based on sheer coincidence. As discussed in Section 3.7, this is an undesired situation because we might erroneously confirm hypotheses.

Another risk is that we must pay attention to which statistical models are used. The answers on questions will supply us with several types of data (nominal, interval or ordinal measurement), which will each need their own statistical approach. This will also be discussed in Chapter 5.

Chapter 4.
FinCom organizational background

THIS chapter elaborates on the enterprise FinCom. The EA organization at FinCom is discussed as well as the phases that are passed during a project.

4.1. Structure of FinCom

FinCom is a financial company that has its headquarters in the Netherlands. This research has been performed for the BUNL (Business Unit Netherlands) of FinCom. BUNL is divided into business and service centers. The Business Center is divided into two value centers which serves two market segments: one for consumer clients and the other for corporate clients. The value centers are supported by service centers. One of these service centers is the Information Services (IS) center, which serves 7 business domains within BUNL. A domain encapsulates a group of functions related to each other. An example of such a domain is 'input handling' which processes all documents that enter the company and digitizes them. Each domain has its own architecture specified (the Domain Architecture), which consists of a business architecture and an IS architecture. This research is executed in behalf of the IS service center. The IT part of FinCom is outsourced.

For reasons of confidentiality we can not elaborate deeply on FinCom.

4.2. Road-map for starting a project

When some department of FinCom wants to acquire resources to start a project, a business study is performed beforehand. In this business study possible project risks as well as opportunities are assessed and several deliverables are produced. Two of them are the Business Area Definition (BAD) and the System Architecture Document (SAD). These documents represent the blueprints of the project from, respectively, functional and implementation level. Other deliverables in the business study are the Project Requirements List (PRL) and the project proposal (PP). The PRL describes what the problem in the current situation entails and the project proposal contains the time line of the project and the budget specified for each phase. The start date and the planned end date are also incorporated in the proposal [1].

[1] These data are required when calculating the time and budget overrun.

FinCom has a specific way of focusing on architecture conformance. In order to provide a stimulus for developing under a predefined architecture, the CAG ("Centrale Architectuur Groep") has been constituted. This committee monitors whether the projects that are executed are constructed in line with the Domain Architecture (DA)[2]. When the business study phase has been completed, an Architecture Analysis (AA) document is constructed in which is described whether the SAD is compliant with the domain architecture. The problem owner then contacts the CAG for requesting a "building permit" based on the SAD and the AA document. This building permit represents an approval of the CAG that functions as a permission for starting the project. This permission excludes financial information and is only a confirmation for the conformance of the business and system design to the architecture. The building permit is issued when the BAD/SAD documents are in line with the existing domain architecture, according to the CAG. However, when this is not the case, a building permit can contain several conditions that are expected to be met later on in the project.

After the decision of the CAG the problem owner heads to the PPG (Project Portfolio Group) . This PPG consists of a group of high level managers, for instance the head of the IS center of BUNL. The decisions that the PPG is authorized to make, involve decisions that are above domain level. The PPG decides whether the project should take place and, if confirmed, provides the necessary project resources. In making these decisions, the PPG is advised by portfolio managers; in most cases these portfolio managers work for one specific domain. In their decision for providing budget for the project, the PPG takes a possible issue of a building permit into account as well.

Once the budget has been acquired for the project, the project will start and the Functional Model Iteration (FMI, see Section 4.3) phase will start.

During the DBI phase (the phase in which the project deliverables are constructed, see Section 4.3), a change request (a request for a change in project scope) might arise. This change has to be approved by the steering committee (see Section 4.3), and, if necessary, acquired budget will be arranged in the same way as at the start of the project.

4.3. Stakeholders and phases during a project

Project manager (PM) Guides the IT project (the projects in this research are IT projects) and is responsible for time and budget constraints in the project

Steering committee Belongs to a domain and its task is to steer the project in the right direction and monitoring its risks and opportunities. The project manager has to report the progress in the project to the steering committee. This committee can overrule the project manager and make decisions for the project life cycle. When considering large, strategic projects, it matters greatly that this steering committee is a skillful group. The committee contains positions from both the value centers as the service centers. During the project, the following phases are passed:

[2]The Domain Architecture contains both business and IS architecture and is specified for the domain and its corresponding projects

Functional Model Iteration (FMI) In this phase a prototype that represents the project deliverables is constructed. When constructing this prototype, several risk or project changes might come along. Therefore, the FMI phase is an iterative phase, in order to be able to use feedback from a prototype that did not seem to meet requirements. When changes in the direction of the project in the FMI phase are desired, the permission of the steering committee is required.

Design and build iteration (DBI) This phase, consists of actually constructing the end product. The goal is to fully deliver the product in accordance with the BAD and SAD documents.

Implementation In this phase the product is implemented in the situation where it is developed for. The project has come to an end and the final product is ready for use in practice.

Evaluation. The project is evaluated and feedback is given so that future projects can benefit from this.

4.4. Architects at FinCom

FinCom is split into 7 functional domains. These domains together constitute the business of the enterprise. Each domain has specified its own architecture, which have to be in accordance with the 'general architecture rules' specified within FinCom. Several types of architects at FinCom are responsible for conforming to this architecture. These architects are (schematically depicted in Figure 4.1):

- Enterprise Architect. This IS architect works for one or more domains (see 4.1 on page 47) within FinCom. The Enterprise Architect specifies the domain architecture and his task is to take care that the initial design of the project is set up in line with the domain architecture. He or she has a seat on the CAG and is involved in projects during the business study. The architect's task is to take care that the initial architecture of the project is set up in line with the overarching architecture. When this situation is the case, a building permit is issued.

- Business Architect. This architect also seats in the CAG and focuses on the Business Architecture. He or she operates on all levels, i.e. above domain, domain and project level. The business architect is charged with specifying the business architecture and the compliance of the functional design of projects to the business architecture.

- Domain Architect: This architect works for and has key knowledge of a domain. He or she and is involved in guarding that the projects in a domain are executed in accordance with the domain architecture. Whereas an Enterprise Architect is charged with aligning the design at the start of the project with the domain architecture, the domain architect's task is to supervise that the project is actually

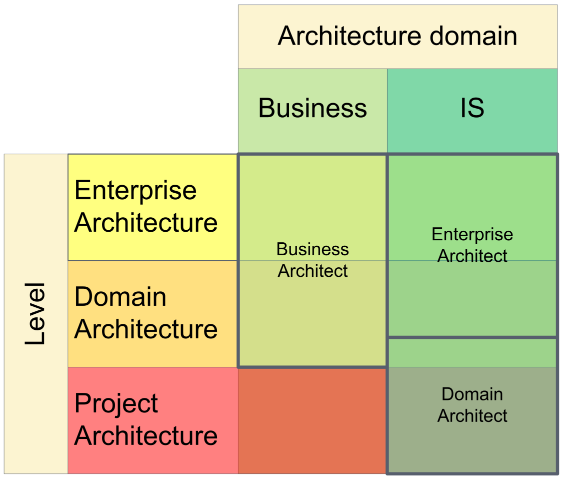

Figure 4.1: *Architecture at FinCom*

executed according to this architecture. Subsequently, when a building permit is issued with the condition to include additional issues, it is the task of the domain architect to address these issues.

These architects are schematically depicted in Figure 4.1.

Chapter 5.

Statistical context

In this chapter we elaborate on the statistical methods that are used in the analysis and some additional background information on statistics is provided. The methods are used in order to find a correlation between project data and to be able to confirm or reject hypotheses.

5.1. Types of data

Quantitative data can be grouped into two types, continuous and discrete. Continuous data result from measurements on some continuous scale such as length, weight or temperature. These scales are called continuous because between any two values there is an infinite number of other values. For example, between 1.537 cm and 1.538 cm, there are values of 1.5372, 1.5373, 1.53724 and so on.

Discrete data result from counting the occurrence of events or facts. Examples might include the number of paint runs per batch of painted parts or counting the number of valves that leaked.

It is important to recognize the type of measurement scale for collecting data in order to avoid measurement errors. We distinguish four types of measurements scales:

Nominal scales Includes categories of items that have no relation with each other. No specific order between these categories can be assigned. Examples might include a part list of a car, such as tires, steering wheel, brake discs, etc.

Ordinal scales The values in this scale refer to a position in a series, but the precise differences between values can not be specified. An example could include the position of a runner in a marathon (first, second, third).

Interval scales The differences between values are meaningful, but the values have no absolute minimum. An example is the measurement of temperature. In this case, 20 degrees Celsius is not twice as much as 10 degrees Celsius.

Ratio scales The differences between values are meaningful and the values do have an absolute minimum. An example of this is the measurement of length in cm. A length of zero cm equals zero length, and 20 cm is twice as long as 10 cm. Another example of such a scale is the age of someone.

5.2. Descriptive statistics

The purpose of descriptive statistics is to present data in a way that will facilitate understanding. Consider for example the following data set of numbers:

$$\{2, 8, 4, 7, 3, 3, 7, 5, 1, 9, 2, 2, 8, 8, 8\}$$

. The first data presentation that is discussed is the *frequency distribution* shown in Table 5.1. This table shows the amount of times that each value appears in a data set. Graphically, this is depicted in a histogram, which is shown in Figure 5.1.

The diagrams reveal information about the sample that was not obvious from the data list, such as:

- The **spread** of the sample
- An indication of the **shape** of the sample
- An approximation of the **center** of the sample.

These three attributes, spread, shape, and center, are key to understanding the data and the process that generates them.

The **spread** of the sample is also referred to as dispersion or variation (this latter term is used in this research project) and is usually quantified with either the sample range (defined as the highest value minus the lowest value) or the sample standard deviation. The sample standard deviation is the more sophisticated metric and is defined as

$$s = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}$$

where

$x =$ value of variable
$\bar{x} =$ the sample mean or average
$n =$ sample size

. This formula produces an estimate of the standard deviation of the population from which the sample was drawn. If data for the entire population are used (which is rare in piratical applications), the population standard deviation is defined as:

$$\sigma = \sqrt{\frac{\sum(x - \mu)^2}{N}}$$

where

Table 5.1: *Frequency distribution*

x	Frequency
1	1
2	3
3	2
4	1
5	1
6	0
7	2
8	4
9	1

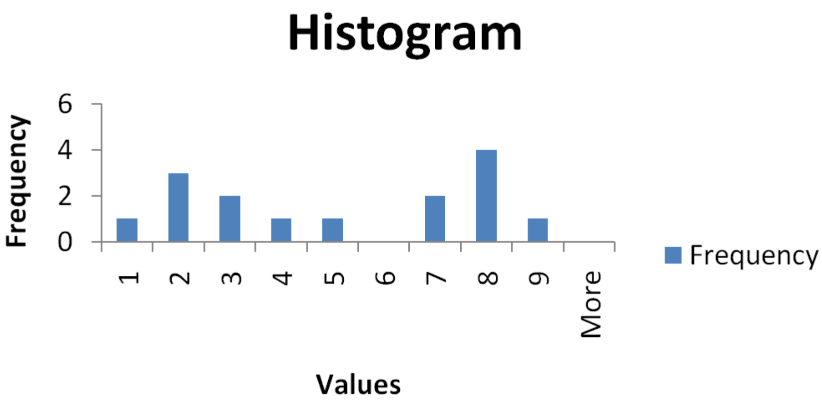

Figure 5.1: *Example of a histogram*

x =value of variable
μ= the population mean or average
N= population size

. The *center* of the sample may be quantified in three ways:

- The mean, statical jargon for the more common word "average"
- The median, which is defined as the value that is in the middle of a sorted list
- The mode, which is the value that appears most frequent in the sample.

In Table 5.2 a summary of these descriptive measures is shown.

Table 5.2: *Summary of descriptive measures*

Name	Symbol	Formula/Description
Measures of Central Tendency		
Mean	$\bar{x}$	$\frac{\sum x}{n}$
Median	$\tilde{x}$	Middle number in sorted list
Mode		Most frequent number
Measures of Dispersion		
Range		High value-low value
Standard deviation		$\sqrt{\frac{\sum(x-\bar{x})^2}{n-1}}$

Clearly, when large enough, the sample represents the population. Each population also has its accompanying probability distribution. The possibility that a specific future event happens, can be derived from this probability distribution.

Probability distributions are mathematically represented by a Probability Density Function (PDF). The characteristics of a PDF are:

$$p(x) \geq 0 \qquad \forall x \epsilon \mathbb{R} \tag{5.1}$$

$$\int_{-\infty}^{\infty} p(x)d(x) = 1 \tag{5.2}$$

. Equation 5.1 denotes the fact that the chance that an event x happens is always equal to or larger than zero. Equation 5.2 means that the sum of the chances for all events x is 1.

Another method of displaying a probability function is the cumulative probability function. In this function, for each X the chance specified for all $x \leq X$. Figure 5.2 shows a graph of such a function.

The cumulative probability function is defined as:

$$cp(u) = \int\limits_{-\infty}^{u} p(x)dx \tag{5.3}$$

, where p(x) is the probability density function.

The Measures of Central Tendency (see Table 5.2) can be derived from the probability functions. For instance, the mean of a population is given by

$$\int\limits_{-\infty}^{\infty} xp(x)d(x) \tag{5.4}$$

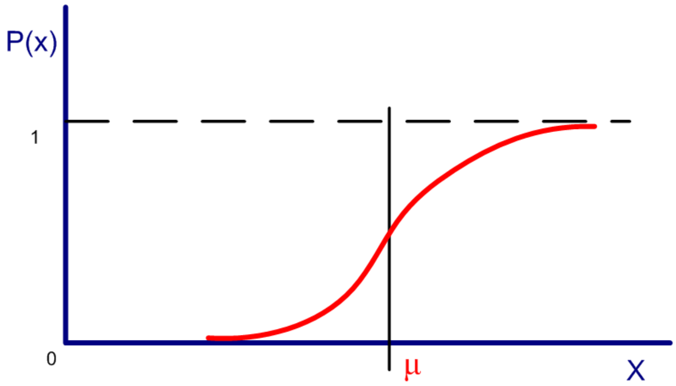

Figure 5.2: *Cumulative probability function*

. Subsequently, the median of a population can be derived from the cumulative probability function. The median is the value of x where the cumulative value is 0.5, given by

$$cp(x) = 0.5 \tag{5.5}$$

. Additionally, the mode of a population is the number that appears the most in the population. Therefore, the mode of a population can be derived from

$$p^{'}(x) = 0 \tag{5.6}$$

where $p^{'}(x)$is the *derivative* of the probability density function $p(x)$

. An important probability density function is the normal distribution. The distribution is characterized by the mean (μ) and the standard deviation (σ). The probability density function for the normal distribution is:

$$p(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}, \qquad -\infty < x < \infty \tag{5.7}$$

. In Figure 5.3, a sketch of the graph of probability density function of the normal distribution is shown.

As can be see from the figure, the further away the values are from μ, the less they appear in the population. For example, approximately 95% of the values are within two standard deviations and about 99.7% lie within three standard deviations from μ.

When a variable is normally distributed, sophisticated methods to compare it with other values can be used. Therefore, it is wise to look for a translation function that translates a histogram (which is in fact a discrete PDF) to one that looks normally distributed (Benbow and Kubiak, 2005). For example, consider the log-normal distribution in Figure 5.4.

If we obtain a histogram such as this, it is advisory to look for a log function that, when applied to the values on the x-axis, produces a normal distribution.

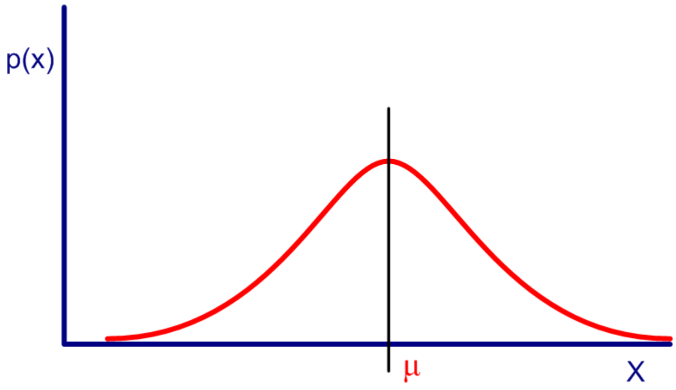

Figure 5.3: *A sketch of the probability density function of the normal distribution*

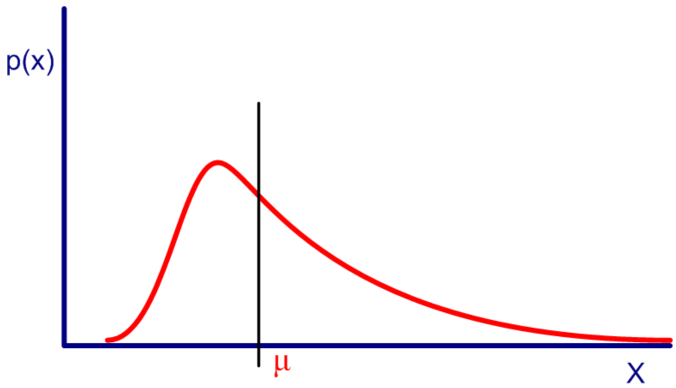

Figure 5.4: *A sketch of the log-normal probability density function*

Another important statistical theory, which might be of use when considering the time and budget overrun figures of projects, is the Central Limit Theorem:

> Let $X_1, X_2, X_3, \ldots X_n$ be a sequence of independent, identically distributed random variables each with mean μ and variance σ^2. Then the distribution of
>
> $$\frac{X_1 + X_2 + \ldots + X_n - n\mu}{\sigma\sqrt{n}} \tag{5.8}$$
>
> tends to the standard normal as $n \to \infty$. That is,

$$P\{\frac{X_1 + X_2 + \ldots + X_n - n\mu}{\sigma\sqrt{n}} \leq a\} \to \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{a} e^{\frac{-x^2}{2}} dx \tag{5.9}$$

(Ross, 2007).

Because the outcome of a single project depends on many small factors, the total set of project outcomes should look normally distributed. However, an important property of the CLT is that the 'distributed random variables' are independent. This is situation is not the case in a project. In a project, the important factors might influence each other. If they influence one another in the sense that one factor is multiplied with the other, the total set of project outcomes will end up in a log-normal distribution as depicted in Figure 5.4 (Redner, 1990).

5.3. Risks

When examining risks that apply to the statistical phase, we must make a distinction between the two approaches that are considered. As discussed in Chapter 3, we distinguish the top-down and bottom-up approach. Considering the top-down approach, we must pay attention that we are specifying the proper hypotheses. These hypotheses can arise from available literature or from assumptions. In view of the statistical analysis, a check whether the specified hypothesis is confirmed in practice can be performed. Since every hypothesis test uses samples of data from the actual population, there is a chance that, although the analysis is flawless, the wrong conclusions are drawn.

When a causal relation is probable, a corresponding hypothesis is defined that states that the relation does *not* exist (the null hypothesis).

Two different errors exist in this case:

- An error of Type I. When this error occurs, the null hypothesis is rejected while it actually is true. The chance that this occurs must be low. Therefore, when analyzing two sets of data, only a high correlation level (a number will represent the correlation) will provide more certainty in rejecting the null hypothesis and confirming the underlying relation. The chance of wrongly rejecting the null hypothesis is called α.

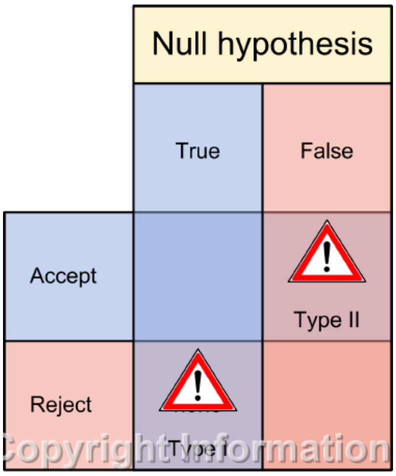

Figure 5.5: *Risks in the top-down/bottom-up approach*

- An error of Type II. This error occurs when a false null hypothesis is not rejected. The chance for this error is called β.

In figure 5.5, the two error types are displayed.

Consequently, we want to minimize the α and β in order to minimize errors in the hypothesis tests.

5.4. Methods used

Given the issues raised in Section 5.2, it is important that we consider what statistical methods we use.

5.4.1. Methods for testing relations among project factors

In order to test whether project factors are correlated, the scale of the project factors has to be determined. Since these data are obtained through interviews, the scale of these values is *ordinal*. After all, the answers that are obtained through the interviews are specified in a one-to-six scale ranging from "completely disagree" to "completely agree" (this is further discussed in Section 6.2.2). Respondent answering "agree" is not twice as much as one answering "somewhat agree". There is an order of the answers, but between the answers there is no equal distance.

Because interviews produce an ordinal scale, we cannot use methods that require a normal distribution in (at least) one of the factors.

Consider Figure 5.6. A hypothesis test between project factors is a nonparametric test, which is defined as:

> "A hypothesis test that does not require the assumption that the population is normally distributed" (Benbow and Kubiak, 2005)

Note that the assumption mentioned here applies to hypotheses of project factors. It is incorrect to view the total set of answers as "normally distributed", because the scale on which the answers are based is nominal.

When following the flowchart in Figure 5.6, we end up with the *Kruskal-Wallis test*, depicted by the circled 1.

The Kruskal-Wallis (K-W) hypothesis test is used to test whether two populations have different medians. It requires independent samples and populations of the same shape. The number of each sample must be larger than five. When the Kruskal-Wallis test returns an α value of smaller than 0,15% , we consider it relevant. In this case, we will perform an additional check whether a trend can be found in the medians.

5.4.2. Methods for testing relations between project factors and project outcome

When we want to compare project factors with project outcome, the choice of the statistical method matters greatly. As stated before, project outcome is defined as the time and budget overrun.

Since a normal distribution of this project outcome is desired (in order to be able to use sophisticated statistical methods), we will, when these data are gathered, check whether we can transform the histogram into a normal distribution. Therefore, when the project outcome turns out to be (log)-normally distributed, we can apply new methods to this calculation. Three methods are applied when examining these data.

According to Figure 5.6, ANOVA can be used in this situation, depicted by the circled 2. ANOVA stands for Analysis of Variance and this method is typically used to determine whether the data formed by the treatment options from a single factor designed experiment indicate that the population means are different.

Another method that is used is Levene's equal variances. Levene's test is used whether to test if two variances are equal. In Figure 5.6, this method is depicted by the circled number three.

The third method is the regression/fitted line test. This test tries to find a linear line that describes the data. In this case, a project factor is set out on the x-axis and the belonging project result on the y-axis. This method returns a value that indicates the chance that the graph can be represented by a straight line.

5.4.3. Clustering method

When two data sets have similar values, a percentage can be calculated which represents the level of similarity between the two data sets. The method will be applied in Section 8.1.2. The method used here is called the "single linkage clustering" (or nearest neighbor) method. The single linkage method determines the minimum distance between two sets of data. In single linkage theory, the distance between these two data sets is decided by the minimum distance between two elements in both sets that are closest to each other.

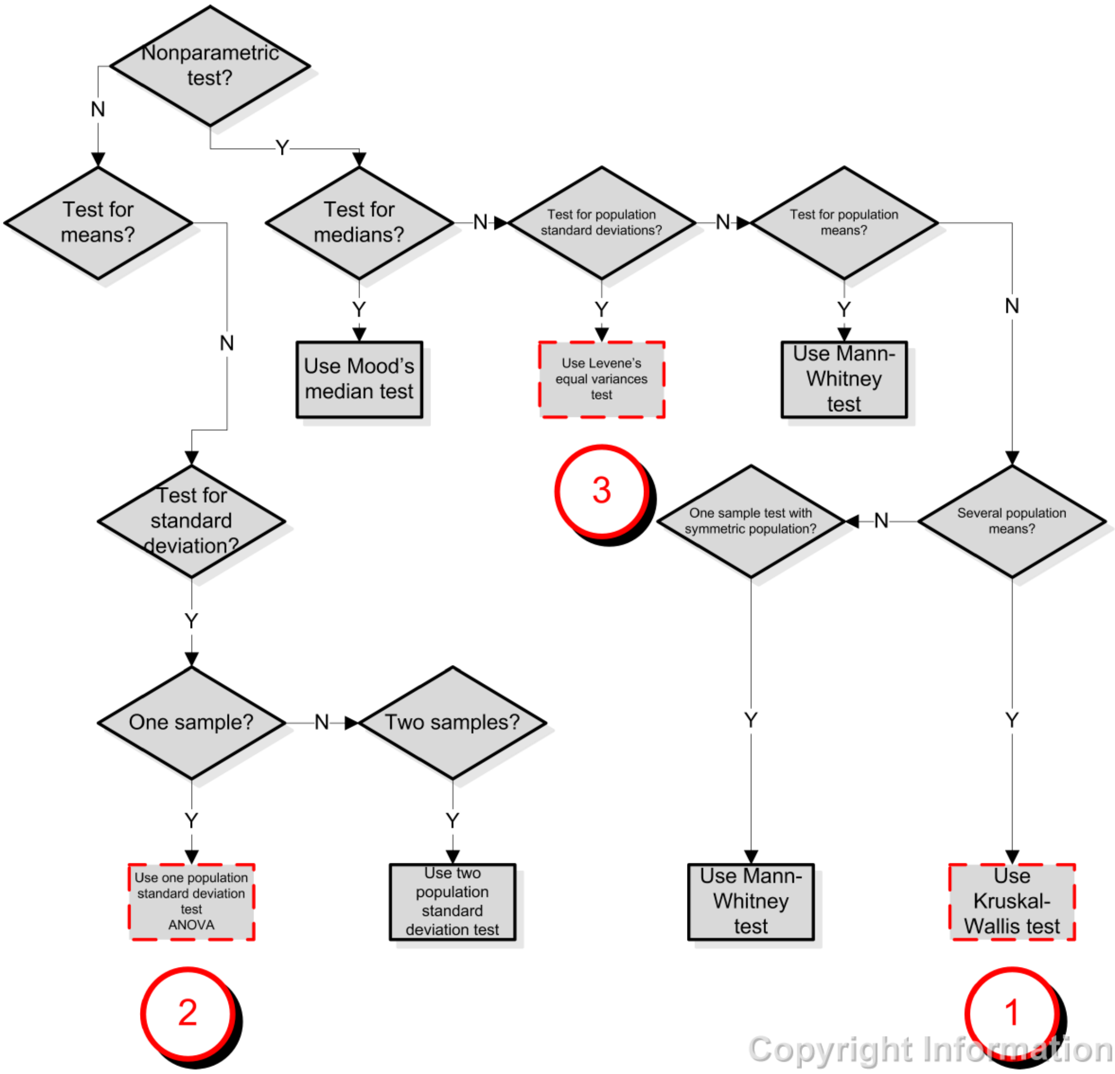

Figure 5.6: *Hypothesis test flowchart (Benbow and Kubiak, 2005)*

Mathematically, the distance $D(X, Y)$ between two data sets X and Y is described by:

$$D(X, Y) = min(d(x, y))$$

where

$d(x, y)$ is the distance between elements and X and Y are two sets of data. Applying this algorithm produces a number between 0 and 100 which represents the level of similarity, with 100 being exactly equal.

Chapter 6.

Data acquisition

In this chapter, the data that form the basis of this research are acquired. The types of data that are discussed are depicted in Table 6.1.

Table 6.1: *Types of data in this research*

Input factors		Output factors	
Project factors	Section 6.2.1	Budget overrun	Section 3.5
Theoretical factors	Section 6.2.3	Time overrun	Section 3.5

In short, the input factors are related to the output factors. The input factors are a combination from project factors extracted from projects augmented with theoretical factors that are derived from theory. The values of these theoretical factors' are composed out of the values of project factors.

6.1. Project selection

In order to get a solid basis on which project data are required, we first need to select the projects that we will include in our research. Therefore we set up a number of project criteria according to which the projects are selected, see table 6.2.

Table 6.2: *Project selection criteria*

Project selection criteria		
1	IT projects only	The scope of the thesis is limited to IT projects
2	Main focus of the project must be on software development	No pure package or infrastructure implementations, to prevent comparing different types of projects with different characteristics
3	Gather projects with architecture and without architecture	To exclude other factors than the value of architecture
4	The Architect and preferably the Project Manager must still be available for an interview	To gather information of the project that is not accessible otherwise
5	Minimum planned cost of 100.000 euros at start of the project, no more than 10 million euros	Exclude very large projects and very small projects. These projects may need a different approach

Project selection criteria		
	Description	**Rationale**
6	Start of project execution no longer than three years ago	Obtain recent projects to gain accurate information from Project Manager/Architect
7	Project must be finished or in the last phase (i.e. the project results must be known)	The results of the project must be available
8	Project must involve more than 5 developers	To have a minimum size of the project in order to dispel project simplicity
9	Project information must be available and reliable	To guarantee a trustworthy outcome
10	If projects contain off-shoring it must be clear which parts are off-shored	We want to evaluate the influence of off-shoring projects
11	If a project has both package implementation and bespoke software development we must be able to isolate the development part from the package implementation part	Not to confound different types of activity (lower priority)
12	Gather BUNL projects from various units	Not to have only Operations, or Credits or Front-End projects but to balance the projects (lower priority)

After these criteria were applied to the project database of FinCom, we ended up with 40 projects. The data of these 40 projects are the basis of the research.

6.2. Input factors

In this section we will regard all project data that will be related to the time and budget overrun. Two types of input factors are considered:

1. Project factors; these factors are directly related to the questions posed in the interviews. These factors are constructed in particular for FinCom. Therefore, these factors will contain terms that are well known within this enterprise. These factors are discussed in Section 6.2.1.

2. Additional factors; these factors are added for several reason. They are described in Section 6.2.3.

6.2.1. Project factors

In this section we will discuss the project factors that are incorporated in the research. These project factors are set up on mutual agreement with other employees from Capgemini. The factors correspond with questions that are posed during the interviews. It is important to at least involve the most substantial factors that influence the outcome of the project. In order to reach this, an extra step of specifying several categories to which these project factors belong is performed. These categories are assumed to represent the areas in a project in which flaws can appear. These flaws are considered to have major influence on the outcome of the project. The project factors, grouped according to their category are portrayed in a mind map in Figure 6.1. In Appendix A, a larger view on this mind map is included.

The designated categories are:

- Architecture
  In this category, architecture factors are incorporated. This category is the most important for this research, since we want to measure the influence of this particular category to the project result.

- Project Management
  This category includes problems that might arise in the management of the project. If there are problems in this area, time and budget keeping will be tough.

- Project Proposal Quality
  This category summarizes the quality of the project proposal. If there are drawbacks in the project proposal, the project is seemingly doomed to fail. That's why the phase of formulating the project proposal is a matter of major concern.

- Results
  This category includes factors that are related to the deliverable of the project. In all examined projects, the deliverable of the project is a software product or the implementation of a software product. The reasons for including this category are somewhat diverse. In one way, we want to acquire data on whether the project deliverables are actually completed in accordance with the specifications in the project proposal. In the other way, we are interested whether the result represents the influence of architecture on the deliverable (for instance, the number of delivered generic services in the end product). These are all results next to the results that output factors represent.

- Skills
  This category concerns the experience and skills of the participating people in the project. The experience is divided into experience that is particularly important for one project and general experience.

- General project variables.
  This category relates to trivial factors such as project name, type. A possible issue of a building permit by the CAG is considered in this category as well.

6.2.2. Collecting project factors

The input factors are collected on an interview basis with employees of FinCom. A questionnaire is used to question the respondents. The questionnaire consists 102 questions and is shown in Appendix B. Note that the questions in the questionnaire are randomized in order to minimize bias in the respondents' answers. This is further explained


Value of architecture
Project Management
Project changes
days to solve issues
project changes
Did the scope size change?
When, where and which project changes occured
According to which process where decisions made?
Project members
How was responsible for project management?
Turnover of project members
monthly team meetings
project leaders in time
steering comittee meetings
Project Stakeholders
stakeholder meetings
of project stakeholders
***Interaction of stakeholders in the project
Project Leader
Did PL manage project scope?
Did PL manage requirements?
Did PL measure project progress?
Did PL measure project code quality?
Did PL deal with project changes well?
Project importance according to PPG
leading client sponsors
Project complexity
International project?
Level of sponsorship
When, where and which function was business staff used
Project Proposal Quality
Project costs
Business staff involved in cost process?
Experience with project type in cost phase
Budget set by PL?
Explain project cost estimization process
Risk review
Quality of external risk reviews?
Quality of the inititial risk reviews?
Project plan review quality
Requirements
Quality of functional requirements
Quality of technical requirements
Quality of acceptance requirements
Was the initial project scope clear?
Consistent, complete, relevant project plan?
When were acceptance criteria known?
Results
Percentage of intitial scope realised?
application services
Did project fit the technical requirements?
Generic services
reused generic services
delivered generic services
Isolated costs of generic services
What where the costs of reusing generic services?
generic services that are reused after the project
Cost savings through use of generic services
Architecture
Business, enterprise, SME architecture
Was the architecture used?
Quality of the architecture?
Implementation team and project team feedback into project?
Involved during budget setting ?
Involved during implementation ?
Involved during communication ?
Has the feedback been incorporated in the architecture?
Percentage of the architecture realized
General items
# of architects
FTE for architecture
Budget for architecture
# of building permits solved/not solved
who was responsible for the SME architecture
meetings between architect & business staff
What architectural change requests existed?
What architecure method was used?
Building permit issued by CAG?
SME architecture
Was the initial SME architecture discussed with the business
Was it reviewed?
Compliance with Enterprise Architecture?
Skills
How was the general experience?
Team
Project Leader
Business architect
SME architect
How was the specific experience?
Team
Project Leader
Business architect
SME architect
General project variables
Name, project code, etc.
function points
project FTE's
Project type
Phases in the project
Plannend time&budget for each phase
Actual time&budget for each phase
Results of the project
Actual budget
Change request
Change request type
AIMS project evaluation
Off shoring used yes/no

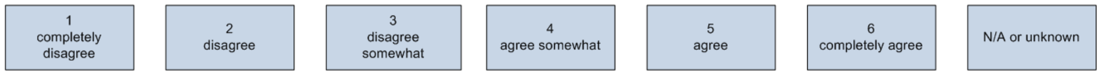

Figure 6.2: *Ordinal scale of questionnaire answers*

in Section 3.6. Another method to reduce the bias in the respondents' answers, is by taking the interviews face to face. The time planned for taking an interview is one hour. The interviewee does not see the questionnaire, and the questions are read to them. The reason for this is to maximize the understanding of the questions. The interviewees are able to ask more specific information on the questions if necessary. This is explicitly told to them before the start of each interview.

When interviewees had participated in more projects, only one interview was taken. The questionnaire was sent to them after wards with the request to fill them in for other projects (that passed the project criteria).

The interviews involved ten business architects, fifteen domain architects, seven enterprise architects and three project leaders. Although these people represent different functions in projects, the interviews were taken ceteris paribus.

The rating of the questions happened on several scales. Most questions were answered on a one-to-six scale, ranging from 1-completely disagree to 6-completely agree. This scale is shown in Figure 6.2.

Nominal scales are involved as well. This situation is the case with questions that are, for instance, about the reason for a project (like question 170). In this case, there is no order in the answers. Numbers are used for storing these answers, but they do not designate any order relation.

Other questions were rated on a ratio scale. This scale is used, for instance, by answering the question about the number of generic services (like question 204).

6.2.3. Additional factors

In addition to the input factors mentioned so far, other factors are added are added to this category, for the following reasons:

- To make the AEM more suitable for use in general EA contexts, apart from being specific for FinCom
- When one single project factor project does not show a relation with project outcome, possibly the addition of factors that are topic related to that single factor will show a relation. Therefore, factors that consist of the addition of the values of project factors are formulated
- To make the model understandable. Additional factors are specified in such a way, that these represent a group of project factors that contain similar content
- To replace several project factors that produced the same results. This is the situation when the answers on questions are very much alike each other. Therefore

it makes sense to replace these questions by a single factor that represents the underlying questions.

These factors do not have their resemblance in the questionnaire (Appendix B), but are included in the AEM for the above reasons. We will call these factors *theoretical factors*.

In Rijsenbrij and Delen (2003) several benefits of architecture are stated. An effort is made in this section to capture these benefits into project variables which will be included in the AEM. Each of the statements of Rijsenbrij and Delen (2003)will be examined and, if a proper project variable can be derived, it is indicated by a number between braces.

"Architecture defines structure and provides an overlook"

This statement contains elements that are not directly quantifiable. However, this topic can be covered by factors from the questionnaire. Therefore, we will capture this project variable as *structure and overlook* {1}. Another project variable that can be recorded is the extent of use of architecture. What Rijsenbrij and Delen (2003) seemingly means is the level of compliancy to architecture. However, the advantages of working with architecture surface only when the applied architecture is compliant with an existing overarching architecture. In conclusion, we will notate the variables structure and overlook {1}, extent of *compliancy to existing architecture {2}* and *quality of existing architecture {3}*. Consequently, if the quality of the existing architecture[1] is not high, it won't have any positive effect on the structure and overlook {1}. The same holds for {2}. The variables {2} and {3} seem to be dependent on each other. {2} makes no sense if there's no {3} and vice versa. Therefore, there is a need for introducing a new variable which we will call *architecture worth {4}*.

"Architecture supports decision making and reduces risks"

In this statement we see that we can reuse the factor architecture worth {4} from the previous statement (because we assume that "architecture" represents the worth of architecture in a holistic meaning). We introduce the new factors *ease of decision making {5}* and *number of change requests {6}*. The number of change requests is considered to represent the risks in the project.

"Architecture ensures that the targets of an enterprise are met and takes care of its business IT alignment"

To explain the above statement, let's take a pizzeria for example. If a pizzeria has in its EA a principle that says that pizza's must be made from cardboard, then the target of selling more than 150 pizza's a month will probably not be reached. Therefore, it is important that the EA is set up in accordance with the targets of an enterprise. Also, if we focus on the part "business IT alignment" in the sentence, we can conclude that the results of this statement are not easily visible in an enterprise. Concluding from this we can say that architecture, among others, improves the functional performance of an enterprise. The results of this statement are not directly noticeable. These results also depend on what is stated in the EA. We might summarize the above as, when using architecture, the enterprise as a whole has better compliancy to its goals and targets. However, since the scope of our research is limited to the value of architecture on project

[1]See Glossary for definition of the quality of architecture

level, we cannot examine these large scale results of architecture. We therefore do not capture this statement in our framework.

"Architecture foresees in guidelines for development and outsourcing"

This statement says something about two benefits of working with architecture: guidelines for development and guidelines for outsourcing. When we take the first benefit into account, we see that these 'development' guidelines have their direct resemblance on project level. As such, the development process in a project will be supported by these guidelines. Therefore we introduce a new variable called *complexity of development process {7}*. The benefit of outsourcing does not need to have its resemblance in a project. For instance, if the EA does not contain any outsourcing-related principles, it is not likely that parts of the project will be outsourced. However, if the EA does contain outsourcing-related principles, it is more probable that parts of the project are outsourced. Concluding, outsourcing depends on what is stated about it in the EA. A positive effect of working with EA is that the IT components of an enterprise are more likely to be built according to the specified IT architecture. Because of the compliance to this IT architecture, the several components of the end product work together in a better way (since they are built according to the same IT architecture). We will capture this as a project variable which we will call *standardized components {8}*. Another reason why architecture leads to standardization is that architecture is applied through the use of architecture frameworks that promote standardization. Standardizing components could work as an incentive for outsourcing in a way that it is easier to outsource a component by taking it out of the original system in such a way that the system' function and operation doesn't change. So we add in the project factor list a new project variable *degree of outsourcing {9}*.

"Architecture uniforms the application of IT"

The verb "to uniform" literally means "make of the same form". Like houses in a residential area are built according to the same architecture, IT can also have "houses" (components) of the same architecture. The architecture statement above seemingly denotes the same as the project variable "standardized components". Therefore, we do not add an extra project variable here.

"Architecture assures readiness for future IT developments"

This statement can be explained by the fact that architecture can provide service oriented solutions. A service oriented environment stimulates the adoption of new technologies as services. Therefore it is easier to adapt new IT developments. Since future IT developments are likely to be compatible with standards and, with {8} in mind, we define a new project variable *readiness for new IT developments {10}*.

"Architecture supports business transformations and migration planning"

A business transformation is made easier since EA also provides guidelines for the business of an enterprise. Because these guidelines provide structure in the web of business processes of an enterprise {1}, it is easier to perform transformations within an enterprise. In the same way, migrations are easier since there is more structure and overlook {1}. As such, {1} links two different statements. Summarizing, we record the project variables *business transformations {11}* and *support for migration planning {12}*.

"Architecture simplifies the use of off the shelf-software"

Because an IT landscape designed with EA is likely to provide more well structured connections between software components (according to {8}), it is easier to fit in off the shelf software. Software that is designed according to an existing EA, is likely to be constructed with market standards. These standards will ease the introduction of off the shelf software. We will capture the project variable *support for off the shelf software {13}*.

"Architecture aids the integration of systems"

The above statement can be explained by the fact that because of {1} and {8}, there is overlook in the project and the project result is encouraged to make use of a component-based, standardized set up. Therefore we introduce the product variable *level of system integration {14}*.

"Architecture stimulates the reuse of proven technology"

This is one of the main key points of architecture. Because architecture helps to define standards and provides overlook, technology components work together in standardized ways. This is what makes it easier to reuse a component. We notate the project variable as the *use of proven technology {15}*.

6.3. Output factors

As stated before, output factors consist of the time and overrun figures of each project. These data were acquired through FinCom's internal database systems. By the management of the database systems, access was provided to this (confidential) information. Both time and budget figures were extracted from these systems. However, when analyzing these data, they seemed to lack quality, as will be discussed in Section 8.2.1.

Chapter 7.

Development of the AEM

In this chapter we will discuss the top down model and how it was constructed. The model is shown in Appendix C.

7.1. Factor categories

Again, the factors specified are divided into categories. These categories exist in order to aid in understanding of the AEM. These factors are somewhat different than the categories of factors as mentioned in Section 6.2.1. A reason for this is that in the AEM not all factors in the category 'results' are included because the cost and time overrun factors are considered as the indicator for project result in the AEM. Additionally, in the AEM there are more factors included, namely the factors that are mentioned in Section 6.2.3. Consequently, the following factor categories exist in the AEM:

- Architecture related variables
  These factors are related to the way in which architecture is applied in the project. It includes topics such as the quality of the architecture and the conformance to this architecture.

- Roadmap/process related variables
  These factors are related to the process of producing a deliverable in the project. 'Project process' is defined as the collection of activities in project that are needed in order to successfully finish the project

- Functional related variables
  These variables are related to the functional complexity of the project. Are the business functions that have to be designed very complex? Are the functional specifications vague so that designing the deliverable is needlessly complex? Did change requests cause complications in the functional requirements phase?

- Social related variables
  These variables relate to the people involved in the project. How experienced was the project team and the architects? Were there enough meetings or was there a lack of communication in the project?

- IT related variables
  This category includes topics such as the technical complexity of the deliverable

and the quality of the technical requirements (which are assumed to influence the technical complexity). Additionally, possible benefits obtained from architecture are incorporated in this category as well. An example of such a benefit could be the reuse of the existing services.

- Business excellence variables.
  This category includes variables that will lead to improved business benefits and prospects. These are the factors that involve the result of the project, except the output factors, since these are considered to represent project success.

7.2. Factors

In this section, the factors that are included in the AEM are discussed. Each factor has been given an ID in order to identify it, which can range from 1 to 601 (not all numbers are used). Factor ID's that have numbers ranging from 1 to 299 have a direct relation to questions in the questionnaire (Appendix B) and they have matching numbers. Not all questions from the questionnaire are considered in the AEM. This is due to several reasons:

- Factors in the questionnaire are not always considered relevant for the AEM.
- Factors are left out in order to keep the AEM simple.
- Some factors in the questionnaire consider the result of the project. The result of a project will be presented by the budget and time overrun, so other result factors are not considered.
- Some project factors produced the same results. This is the situation when the answers on questions are very much alike each other. Therefore it makes sense to replace these questions by a single factor that represents the underlying questions.

Numbers between 500 and 600 relate to factors that were added specifically for the AEM. These factors are surrounded by a thick black line in the AEM and are included for several reasons (as also discussed in Section 6.2.1):

- Factors are added in order to combine multiple factors that have the same topic. Such constructions aim to simplify the AEM. An example of such a construction is given in Figure 7.1, directly taken from the AEM. For instance, factor {522 BA Experience} is combining the factors {211 BA general experience} and {215 BA specific experience}. The added factor (522 in this case) does not correspond to a question in the questionnaire. The value of this factor is defined by adding factor 211 and 215. For all factors that are added, their value calculation is depicted in the "Value calculation"-column in Table D.1. The values in this column are the question answers. Since only values of questions with a nominal scale are added, the theoretical questions also have a nominal scale. There is an order in the values,

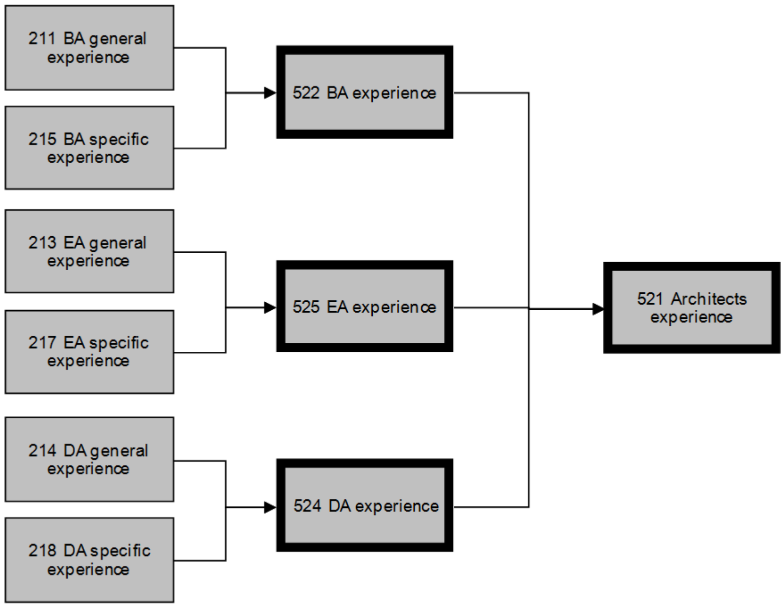

Figure 7.1: *A part of the AEM*

but a value of ten is not twice as much as five. Weigh factors were not included in the model.
Additionally, the meaning of that factor is specified in Table D.1. The relations between factors (depicted by the arrows between factors) portrayed in the AEM are assumed to be *causal relations*. The left side of the arrow specifies the causing factor and the right side specifies the factor that is influenced. This is further explained in Section 7.3.

- Factors that are deducted from theory. Because factors that originate from the questionnaire are specified for FinCom, more general factors are specified with the aid of literature on EA. These factors are discussed in Section 6.2.3.

- When the same answers are obtained for a group of questions, the corresponding factors are replaced by one new factor, and its given an ID ranging from 300 to 399. Statistical analysis produced clusters of questions with the same answers.

- The factors that relate to the time and budget overrun of a project. These are solely the factors 600 (Cost overrun/underrun) and 601 (Time overrun/underrun).

Factors with numbers ranging from 300 to 399 are added because they replace a set of other questions. The represent a set of questions that produced equal answers (because the questions were closely topic related). This is further discussed in Section 8.1.2.

7.3. Relations

The relations discussed in this section are shown in the AEM (Appendix C). The arrows depicted in the AEM represent the relations between factors. On the right side of the arrow, the influenced factor is shown and on the left side of the arrow, the causing factor is located. A continuous line between factors designates an increasing influence on the right factor while a dotted line designates a decreasing influence on the right factor. In Table E.1 for each relation the description is given and, when considered necessary, a reason for this relation. Note that these relations are part of the top-down approach and contain the relations from which is suspected that they *could* exist. The column 'relation ID' corresponds to the numbered relation in Appendix C. The value of a factor that is influenced by multiple other factors is obtained by a calculation on the values of other factors, as explained in Section 7.2.

7.4. Generic AEM

As discussed in our objectives in Section 1.4, a generic AEM is formulated. This is derived from the AEM derived before, however, terms that are specific for FinCom are replaced by terms so that the AEM can be applied to in more cases. The generic version of the AEM is shown in Appendix

Chapter 8.

Data analysis

THIS chapter discusses the analysis on the acquired data. Several steps are taken to improve the quality of the data. Subsequently, correlations between project factors are analyzed.

8.1. Analysis of input factors

In this section, the input factors are discussed and additional steps are taken to improve the quality of the data.

8.1.1. Filtering input factors

Analysis of the input factors shows that some questions do not result in very useful data. The values of all question answers are depicted in the histograms in Appendix G. In order to improve the quality of the data, some questions are left out of the research. Particularly, the questions that have values of which 80% is the same, are not considered interesting. In this case, the answers differ too little to be relevant. The questions shown in Table 8.1 are removed in this steps (this can also be deducted from the histograms in Appendix G)

A second step in reducing the input factors, is removing projects out of the data set for which little data is known. In some circumstances the interviewee finds it hard to remember (some irrelevant aspects for him/her) a project. As a rule of thumb, only when more than 60% of the questions for one project is answered, the project is incorporated in the research. This operation leads to the removal of two projects so we end up with a total data set of 38 projects.

8.1.2. Clustering input factors

Many questions in the questionnaire seem to encompass the same topics. When several question answers produce the same values, these questions are considered to relate to the same topic. In this case, the project factors (that correspond to question answers) are replaced by the introduction of a new project factor. The analytical method that decides whether two variables have the same method is the method of single linkage clustering, as discussed in Section 5.4.3. Two variables are considered equal when their similarity level exceeds 77 (a number between 75 and 80 shows the best results). In this case, a

Table 8.1: *Project factors left out of the research*

Question ID	Description
15	Which party was responsible for architecture?
35	Was the CAG consulted?
43	Number of consecutive enterprise architects on the project
44	Number of consecutive domain architects on the project
51	What percentage of the software was developed off-shore?
133	Building permit issued?
151	Is the project team located across multiple countries?
168	Amount of consecutive leading client sponsor (main sponsor of the project)
171	Estimated cost savings by reuse of generic services by other projects
185	The isolated, specific development cost of the generic services
195	The savings of the project because of the reuse of generic (previously build) services

Table 8.2: *Introduction of new variables*

Variable	Description	Replaces
300	Development team experience	210, 219
301	Was the feedback from the implementation team incorporated in the Domain Architecture?	45, 47
302	Meetings between domain architect & project team during FMI phase	16, 25, 38
303	Architect involvement during budget setting	1, 17
304	Alignment of the domain with EA	189, 191

check is performed whether these variables truly denote the same. Depending on this outcome, a new variable that replaces both is introduced or, when the variables do not mean the same, both variables are kept. This process is shown in Figure 8.1.

Adopting from this figure, in Appendix H factor pairs are shown for which the similarity level exceeds 77. When the variables are considered to mean the same, a new variable is introduced. In Table 8.2, the new variables are shown.

Now, we have constructed the final input data set from which we can start the analysis with output factors as discussed in Section 8.4.

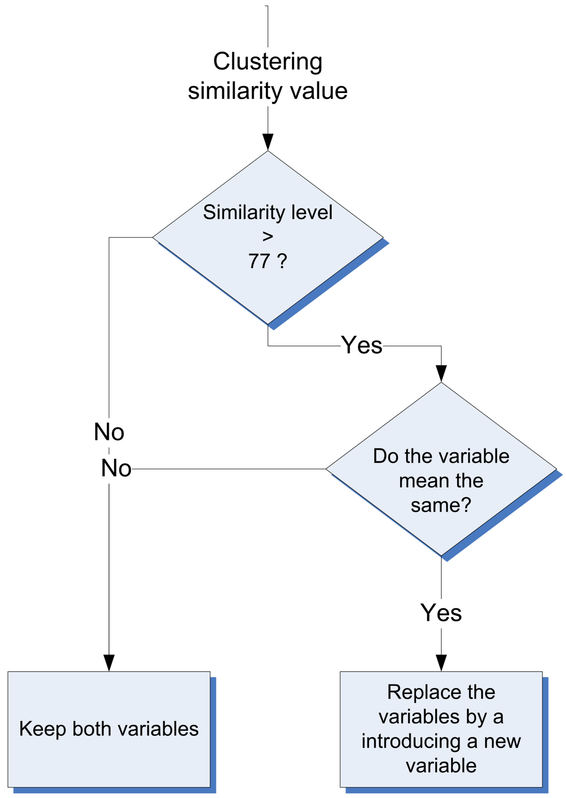

Figure 8.1: *Flowchart of decision for variable replacement*

8.2. Analysis of output factors

In this section, the results of the gathering of output factors are discussed. The data are analyzed in order to define whether they are distributed (log)normally and, subsequently, their quality is discussed. 72 projects were used for these calculations. Note that this amount is higher than the number of projects (38) where answers for the questionnaire are obtained from. Using more projects provides more accuracy when trying to find a probability function on the distribution of project output factors.

8.2.1. Analysis of the cost output factors

As stated in Section 3.5, the following data are needed for the output factors representing cost overrun:

B_a = the amount of capital expenditures that was spent to complete the project
B_p = the amount of capital expenditures in the original estimate to complete the project

First, both data are retrieved from FinCom's internal systems. However, analysis of the cost output factors gathered through FinCom's internal systems showed a maximum overrun of 5%. However, since FinCom's management severely doubted this outcome, it turns out that the dependability of these figures is very low. Seemingly, these figures contain flaws, and therefore an attempt is made to retrieve the figures in another way where possible. Consequently, all project proposals are collected and B_p is extracted from them. When plotting these data on a log-normal scale, and, after removal of outliers, the graph in Figure 8.2 is obtained. Analysis of 72 projects showed that budget overrun was log normal distributed, with parameters: Threshold: 23.5, Location: 4.75 and Scale: 0.56.

This graph shows a more trustworthy outcome and, consequently, these latter data are used.

8.2.2. Analysis of the time output factors

As discussed in Section 3.5, the following data is needed for calculating the time overrun:

T_a = the amount of time that was spent to complete the project
T_p = the amount of time expenditures in the original estimate to complete the project

Both data are retrieved from FinCom's internal systems. In Figure 8.3, the graph of plotting these data is shown. Time overrun is log normal distributed with parameters:

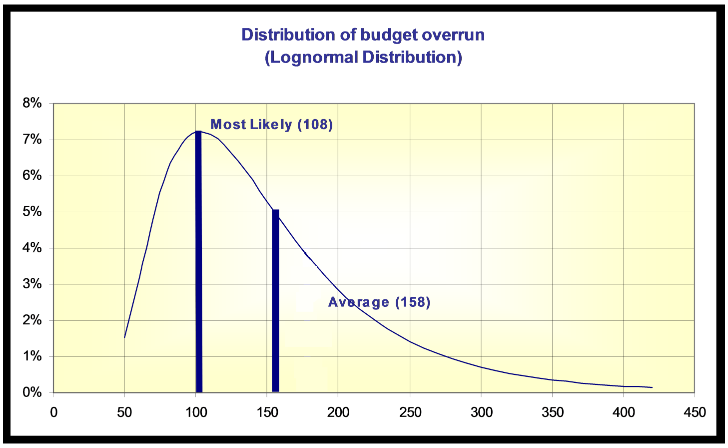

Figure 8.2: *Probability plot for budget overrun*

Threshold: -17.3, Location: 5.09 and Scale: 0.7. Unfortunately, only from about 15 projects sufficient info was available.

The relations between time and budget overrun have also been examined. However, they don't show any relation. An explanation for this is probably that both overruns have different causes. For instance, time overrun can happen when other projects are not able to deliver on time. In this case, the resources of the project can be used for other purposes, such that the budget is not affected. Budget overrun, however, involves more resources since problems have shown up in the project. This involves higher costs, but does not necessarily involve time overrun.

8.3. Specifications of the total data set

At this point, we have collected the data of 102 questions for 38 projects. These questions have been translated into project factors. After adding and deleting several project factors for previously mentioned reasons we end up with a total of 106 project factors for 38 projects.

8.4. Input-output relations

When analyzing the input-output relations, three different properties of the data were analyzed. Appendix I shows the results that were found after the application of these methods. In this table, a "T" stands for a trend being found and a "C" means that there is a correlation. The following statistical methods were used:

- ANOVA (depicted by the "A" in Appendix I.)
- Equal variances (depicted by the "V" in Appendix I)
- Regression/fitted line (depicted by the "R" in Appendix I)

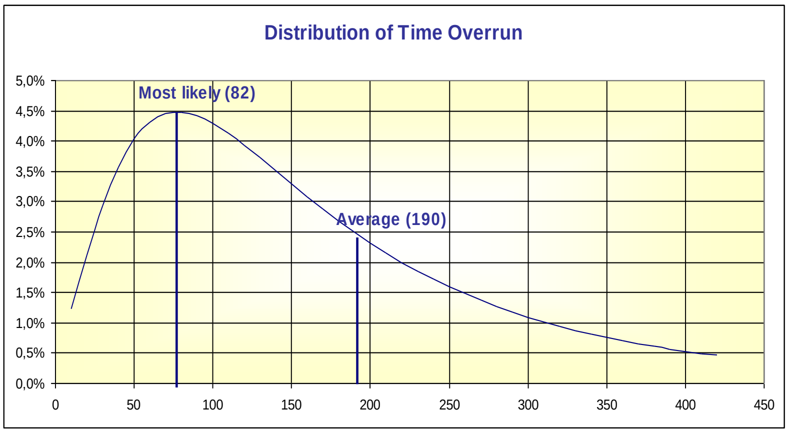

Figure 8.3: *Probability plot for time overrun*

Correlations with time overrun As can be seen from the table in the Appendix, the relations with time overrun suffer from not having enough data available to draw conclusions. no relevant and significant correlations were found. This can be attributed to various reasons:

- The amount of projects investigated (which form the *data set*) is not large enough to find correlations
- The factors specified do not influence the time overrun

Note that these risks have been discussed in Section 3.7.

Correlations with budget overrun The factor correlations with time overrun show little correlations, also after outliers removal. However, some conclusions can be drawn from the data:

- Domain architect experience influences, on average, 12% of project budget overrun
- Higher quality of technical architecture improves predictability of budget planning, the average overrun decreases from 200 to 160

8.5. Input-input relations

These relations will form the basis for the bottom-up model. This phase examines relations between input factors. We find it interesting to find relations between input factors; they might provide a better understanding on how the value of EA can be established on project level. In order to confirm a correlation between two factors, several methods are used to test the correlation of the factors. These methods delivers an α value, that represents the chance of erroneously rejecting an hypothesis, as discussed in Section 5.3. To test whether the 106 input factors are truly correlated, several methods are used and tested successively as depicted in Figure 8.4.

The Kruskal-Wallis method (K-W) is the basis of this flowchart. In the third step, it is tested whether the number of values for each category is larger than 5 (N $>$ 5) and whether a trend can be found in the medians (M). All 106 factors are tested on their relations with the remaining 105 factors, leaving a total of 11.130 K-W calculations. To give an idea how these correlation are spread, see Appendix J, where K-W values between 0 and 0,05 are colored green and values between 0,05 and 0,1 are yellow.

For each α-value that is below 0.1, a possible explanation for the relation is sought. When an explanation is found for them, the relation is stored in the table in Appendix K. The corresponding explanations are discussed in Section 9.1.

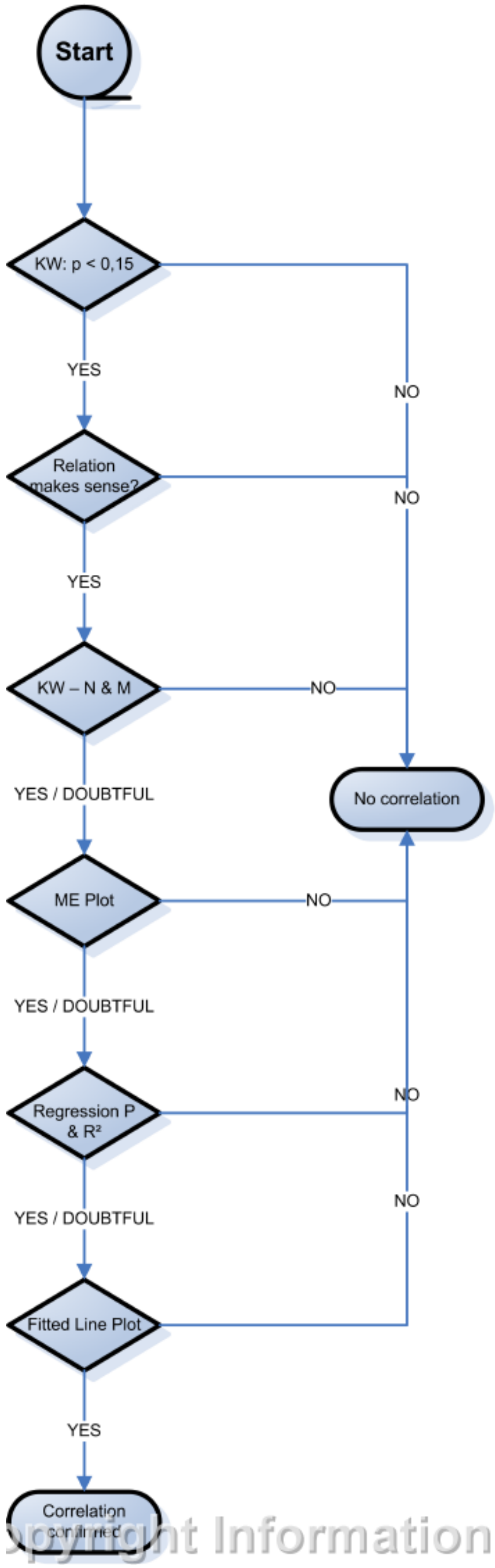

Figure 8.4: *Flowchart for determining statistical correlation*

Chapter 9.

Implementing results of statistical analysis

In this chapter, the results of the statistical analysis are discussed. The bottom-up model is developed and subsequently, the AEM is augmented with the results of the statistical analysis (resulting in the *extended* AEM).

9.1. Development of bottom-up model

In this chapter, the results of the statistical relations that have been found in Section 8.5 are discussed. The relations are examined for a possible explanation. These relations do not involve relations to output factors, since these are already discussed in the top-down approach.

In Table L.1, the relations that are found in Section 8.5 are shown and the corresponding explanation is given.

When these factors are linked together in a model, the bottom-up model can be derived, as shown in Appendix M.

9.2. Extended AEM

In Appendix N the *extended AEM* is depicted. This is obtained by augmenting the original AEM with the relations from the bottom-up model. After this junction, it becomes clear what hypotheses are confirmed. The hypotheses that are confirmed, are not much surprising. However, we want to mention two hypotheses here:

- A higher worth of architecture leads to the delivery of generic services
- A higher worth of architecture leads to the reuse of generic services.

This is what we expected, however, we have now confirmed according to the scientific method that these hypotheses are true. One can claim that architecture delays or reduces the delivery and reuse of generic services, however, we have now proved that this is not true.

All hypotheses in the AEM that are confirmed, are depicted as such in the AEM. All relations from the bottom-up model are included as well. Some factors that were not but in the bottom-up model are included. These operations lead to the *extended AEM*. See the legend in the AEM for a more accurate explanation.

Chapter 10.

Conclusions and future work

10.1. Conclusions

THE goal of this thesis is to assess the added value of EA. The main thesis question has been defined as:

> What model can be used for assessing the added value of Enterprise Architecture in IT projects?

The answer to this question is: **the Architecture Effectiveness Model**. Despite the fact that the research that led to the model is new and is performed in an unexplored area (namely the assessing of the added value of architecture), the results are promising. The AEM incorporates factors that represent groups of factors and this approach produces valuable results. In this way, influences have been found that would not have been found when the influence of single factors is examined. This approach makes assessing the value of EA in enterprises more accurate.

In order to come to the answer above, several objectives had to be met, according to Section 1.4. Due to the nature of this research, namely the matching of theory with practice, the objectives are twofold. Theoretical objectives as well as practical objectives are considered.

Theoretical objectives

1. **To *seek* approaches in literature that aim to assess the added value of architecture**
   Several literature documents have been discussed, however, none of them produced models that can be used for such purpose. Some frameworks have been discussed for defining the value, but these approaches did not offer concrete assessment techniques.

2. **To *deliver* a model that can function as a method for assessing the added value of Architecture in general EA contexts (not only for FinCom)**
   The model produced is called the Architecture Effectiveness Model (the generic

version). The integrity and validity of this model is guaranteed by the following subordinate objectives:

a) **To *establish* a method that uses a scientific approach**
In order to fulfill this objective, two different techniques are discussed. Six Sigma is combined with the scientific method. This application of two techniques lead to the following approaches: top-down and bottom-up. Top-down implies the formulation of hypotheses and their validation by practice. Hypotheses on how EA influences project success are set up and these hypotheses are statistically tested. In the bottom-up approach, all statistical relations that have been found are examined for a possible explanation and, when their relations make sense, they are incorporated in the bottom-up model. Subsequently, both models will be merged which will result in the final *extended AEM*.

b) **To *determine* statistical methods that can be used for data analysis**
Two different types of data analysis can be indicated:

- Correlations between factors that both have a nominal scale.
  - For this analysis, the Kruskal-Wallis method is used.
- Correlations between factors of which one has a nominal scale and the other an ordinal scale that is (log)normal distributed. The following methods are used in this situation:
  - ANOVA
  - Regression / fitted line test
  - Levene's test

c) **To *define* factors in projects representing project success**
The value of architecture appears on three levels: -*Strategic level*

-*Tactical leve*l
-*Operational level* For this research, the value of architecture on operational

level is chosen. Since the value of architecture on operational level focuses mainly on reducing cost and saving time, a cost-time approach is chosen. The approach for such a research is to compare the application of EA in projects with the time and budget overrun of these projects. Consequently, a project is considered successful when the project is finished within the planned budget and time. This enables us to use a set of methods that is able to consider a heterogeneous set of projects. The factors time and budget overrun are called *output* factors.

d) **To *define* factors in projects influencing the project success**
This objective leads to the definition of project factors that relate to project success. These factors are called *input factors* and contain both architecture oriented factors as well as non-architecture oriented factors. This is necessary since non-architecture oriented factors can also influence project success. Some factors are directly related to questions in the questionnaire. The questionnaire has been obtained externally and is out of scope for the research. Other factors are added for several reasons:

- Factors are added in order to combine multiple factors that have the same topic. Such constructions aim to simplify the AEM.
- Factors that are deducted from theory. Because factors that originate from the questionnaire are specified for FinCom, more general factors are specified with the aid of literature on EA.
- When the same answers are obtained for a group of questions, the corresponding factors are replaced by a new factor

Practical objectives

1. **To *deliver* a model that can function as a method for assessing the added value of Architecture at FinCom**
The model produced is called the Architecture Effectiveness Model. This model is used in order to assess the value of Architecture at FinCom.

2. **To *produce* convincing arguments for Enterprise Architecture investments**
These arguments are derived from the findings that result from the application of the model. The findings show the benefits of EA and are formulated as recommendations that evidently lead to arguments for architecture investments. Concluding from the findings depicted in the subordinate objectives below, a distinction is made between factors regarding project budget and factors regarding project quality. The following recommendations for FinCom can be formulated:

   - <u>*Recommendations regarding project budget*</u>
     - Focus on the quality of the technical architecture. When the quality of the technical architecture is high, the baseline budget for the project varies less compared to the actual budget then with lower quality of technical architecture. The average budget overrun decreases in situations with high quality of technical architecture from 200 to 160.
     - Aim to put together a team of domain architects with high experience. The experience of the domain architect influences the budget overrun. An average of 12% budget overrun can be explained by the experience of the domain architect.

  - Focus on executing the projects in alignment with the business architecture. When a strict alignment to the business architecture is adhered, a decrease of costs for future project can be noticed.
  - Have enough architects meetings. Architect meetings are valuable meetings that contribute to the decrease of operational costs in the domain.
  - Stimulate the reuse of generic services (by strict alignment with architecture). The reuse of these services will lead to a decrease in future project costs

- <u>*Recommendations regarding project quality*</u>
  - Execute the projects in line with architecture. The reuse of delivered generic services is demonstrably higher. Since the reuse of delivered generic services leads to a decrease in future project costs, architecture decreases future project costs.
  - Execute the projects in line with architecture. The delivered generic services will be higher. Two months of architecture work is related with, on average, one reused shared service. This relation is an hypothesis that was confirmed according to the scientific method.
  - Make sure the projects are aligned with architecture ànd guarantee the quality of the domain architecture. When these requirements are met, this will lead to the delivery of generic services. This relation is also an hypothesis that was confirmed according to the scientific method.
  - Reassure that each domain has a pre-documented business architecture. Having a pre-documented business architecture leads to better definition of the acceptance requirements in projects.
  - We found that the quality of the functional requirements correlates with the business value. This is an interesting finding. When the business value is high, it is likely that the functional requirements are specified with care and result in high quality requirements. However, even more interesting is the relation the other way: when the functional requirements are higher, the business value increases. When this would be true, a truly valuable relation is found. This implies that the quality of the functional requirements is crucial for having high business value. Unfortunately, we were not able to find in what direction the relation is here.

a) **To *assess* the added value of Enterprise Architecture at FinCom in quantitative data**
This are the findings that result from the application of the model. These findings correspond with the relations found between input and output factors. The following relations have been found that indicate the value:

  - Higher quality of technical architecture improves predictability of budget planning, the average budget overrun decreases from 200 to 160

- Domain architect experience influences, on average, 12% of project budget overrun

b) **To *pin-point* factors in IT projects of FinCom that qualitatively relate to each other**
Other factors then architecture factors are also considered in these relations. These findings correspond with the relations found between input factors. A distinction is made between relations regarding cost and relations regarding quality:

- *Relations regarding cost*
  - A higher project compliance to the business architecture leads to a decrease in costs for future projects (similarity level 0,077)
  - The number of architect meetings lead to a decrease of operational costs in the domain (similarity level 0,012)
  - Reuse of delivered services leads to a decrease in future projects costs (similarity level 0,073)
- *Relations regarding quality*
  - An average of 5-6 generic services are reused when project was executed with architecture, while 1-2 generic services were reused when project was not executed with architecture
  - Architecture increases reuse of delivered generic services. Two months of architecture work correlates with the delivery of, on average, one reused shared service
  - When the architecture is complete, up-to date, consistent and relevant and a project is compliant to the architecture, this will lead to the delivery and reuse of generic services (similarity level 0,05)
  - The existence of a pre-documented business architecture leads to a better definition of the acceptance requirements (similarity level 0,019)
  - The quality of functional specifications correlates with the business value (similarity level (similarity level 0,01)

10.2. Discussion/reflection

It turned out that the quality and quantity of the output data was an important issue. The output time factors did not have the quantity desired. Unfortunately, only from about 15 projects sufficient info was available and no relevant and significant correlations were found. Therefore, the time benefits can not be derived from this research.

When the management of FinCom was confronted with our first analysis of the output budget data, it appeared that the figures were not consistent with reality. Subsequently, the output budget data were retrieved in other ways. Some meaningful relations have been found when examining relations with these factors. The output budget factors seem to embrace more quality than the output time factors. However, for establishing these relations not always enough data for exact conclusions was available.

The relations between time and budget overrun have also been examined. However, a relation between these could not be found. This could also be caused by low quality output factors. Another explanation for this is that both overruns have different causes. For instance, time overrun can happen when other projects are not able to deliver on time. In this case, the resources of the project can be used for other purposes, such that the budget is not affected. Budget overrun, however, as for more resources since problems have shown up in the project. This involves higher costs, but does not necessarily involve time overrun.

Summarizing, the relations with the output factors did not meet our expectations. The relations between the input factors seem to deliver more meaningful results. These input factors were established in a situation where we were in control (the interviews). Consequently, we attach more value to the relations among input factors.

Regarding the objectives set in Section 1.4, the theoretical objectives are met. The model has been produced and can be used for application in further projects that are executed by FinCom or other enterprises. Regarding the practical objectives, these are partially met. Relations with budget overrun have not been found, however relations between input factors provide interesting results.

Another fact that is worth mentioning here is that FinCom has a typical way of committing architecture. FinCom considers an architect as being 'a person of rank'. This implies that an architect is not concerned with the budget of a project. An architect's job is to design projects according to the domain architecture, indepent from additional cost that his/her design brings. This is an approach that can entail problems in setting the budget for projects. It might result in situations where the design process is settled, and, subsequently, architecture overshoots the mark.

The reason that little research exists on this topic can probably be explained by the fact that its hard to show quantitative relations. However, this research has shown that promising results can be obtained from a quantitative approach in applying the AEM.

10.3. Future work/recommendations

Our research focused on project level and considered time and budget data representing project success. However, future work can focus on other factors than the budget and time overrun. Future work can, for instance, tackle the long term value of architecture, by examining it on tactical and strategic level, However, since architecture is a concept that is continuously subject to changing business and IT environment, it make the long-term value assessment of architecture a complex matter.

An interesting additional research would be to assess the value of architecture for several lines of business. Since the value has been examined for a financial company here, we suggest the application of the AEM in other lines of business as well. However, the AEM is constructed with the application for all types of business in mind, so it would be interesting to examine this.

Another approach for future work could be to focus solely on technical architecture. In order to quantitatively assess EA in this way, a factor that quantifies project success has to be indicated. In the situation for FinCom, for instance, the time it takes for a client to open a bank account can be used as this factor.

We learned that future work that uses the AEM should focus on assuring the quality and quantity of output data. We cannot determine whether more relations would have been found if more data had been used. In this case, the project selection criteria would need to be weakened, but that is something from which we stated that it is not desirable.

As an recommendation for enterprises implementing EA we can conclude: each enterprise should engage in the value of architecture in order to give feedback to the architecture for improving future application and, as such, realizing EA as the 'key to success'.

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Glossary

AA see Architecture Analysis

added value of EA The specific value delivered by architecture to the business and IT environment. The term 'specific' refers to the fact that it represents the value of the result of EA that is achieved compared to the value of the result that would have been achieved if EA was not applied

AEM see Architecture Effectiveness Model

ANOVA ANOVA stands for Analysis of Variance. This method is typically used to determine whether the data formed by the treatment options from a single factor designed experiment indicate that the population means are different.

architecture Architecture is the normative restriction of design freedom

Architecture Analysis A document in which is described whether the SAD is compliant with the domain architecture

Architecture Effectiveness Model A model that contains hypotheses on the use of architecture in an IT project and, as such, shows the relation of these factors to the budget and time overrun in a project

BA context dependent; see business architect or business architecture

BAD see Business Area Definition

BUNL Business Unit Netherlands

business This term is context dependent, but mostly refers to: The activity of providing goods and services involving financial and commercial and industrial aspects

business architect This architect also has a seat on the CAG and focuses on the Business Architecture. He or she operates on all levels, i.e. above domain, domain and project level. The business architect is charged with specifying the business architecture and the compliance of the functional design of projects to the business architecture.

Business Area Definition represent the blueprints of the project on functional level

CAG see Centrale Architectuur Groep

Centrale Architectuur Groep committee monitors whether the projects that are executed are constructed in line with the Domain Architecture (DA)

Change request A request for a change in project scope. This can be caused by several reasons, such as feasibility reasons. This change has to be approved by the steering committee.

DA context dependent; see domain architect or domain architecture

DBI see Design and Build Iteration

Design and Build Iteration This phase consists of actually constructing the end product. The goal is to fully deliver the product in accordance with the BAD and SAD documents.

domain architect This architect works for and has key knowledge of a domain. He or she and is involved in guarding that the projects in a domain are executed in accordance with the domain architecture. Whereas an Enterprise Architect is charged with the design at the start of the project in line with the domain architecture, the domain architect's task is to supervise that the project is actually executed according to this architecture. Subsequently, when a building permit is isssued provided that several issues will be implemented, it is the task of the domain architect to address these issues.

Domain Architecture The Domain Architecture contains both business and IS architecture and is specified for the domain and its corresponding projects

EA context dependent; see enterprise architect or enterprise architecture

enterprise A purposeful or industrial undertaking

enterprise architect This IS architect works for one or more domains (see) within FinCom. The Enterprise Architect specifies the domain architecture and his task is to take care that the initial design of the project is set up in line with the domain architecture. He or she has a seat on the CAG and is involved in projects during the business study. The architect's task is to take care that the the initial architecture of the project is set up in line with the overarching architecture. When this situation is the case, a building permit is issued.

FMI see function model iteration

FTE see full time equivalent

full time equivalent The amount of hours in one workweek, indepent from the number of employees that might have contributed to these hours

Function Model Iteration In this phase a prototype that represents the project deliverables is constructed. When constructing this prototype, several risk or project changes might come along. Therefore, the FMI phase is an iterative phase, in order to be able to repeatedly test the deliverables. When changes in the direction of the project in the FMI phase are desired, the permission of the steering group is required.

generic service a service that is developed with the aspect of reuse in mind. This term seems pretty vague, but a generic service is used for many things that have these characteristics within FinCom

governance the process of utilizing, maintaining and improving Enterprise Architecture

input factors Factors that will be correlated to the output factors. Input factors are the factors in a project which values distinguish the project from other projects (like the number of people in the project, level of technological complexity, etc). Some values of these project factors will also denote the position of EA in the project (i.e. how was the quality of architecture, etc.). Factors that consider the result of the project are included in this category as well, however, the budget and time data are in the output factors

K-W see Kruskal-Wallis method

Kruskal-Wallis method test is used to test whether two populations have different medians. It requires independent samples and populations of the same shape. The number of each sample must be larger than five. When the Kruskal-Wallis test returns a value of smaller than 0,15

Nonparametric test An hypothesis test that does not require the assumption that the population is normally distributed

output factors Data that are known at the end of the project. The output factors are time and budget overrun for each project

PM see project manager

PP see project proposal

PPG see project portfolio group

PRL see project requirements list

project architecture project architecture is the prescriptive notion of architecture that is used in a project in order to align it with the overarching Enterprise Architecture. All notions of architecture in FinCom are considered to be prescriptive.

project manager Guides the IT project (the project in this research are IT projects) and is responsible for the time and budget constraints in the project

project portfolio group consists of a group of high level managers, for instance the head of the IS center of BUNL. The decisions that the PPG is authorized to make, involve decisions that are above domain level. The PPG decides whether the project should take place and, if confirmed, provides the necessary project resources. In making these decisions, the PPG is advised by portfolio managers; in most cases these portfolio managers work for one specific domain. In their decision for providing budget for the project, the PPG takes a possible issue of a building permit into account as well

project process the colllection of activities in project that are needed in order to succesfully finish the project

project proposal Contains the time line of the project and the budget specified for each phase.

project requirements list describes what the problem in the current situation entails and the project proposal contains the time line of the project and the budget specified for each phase.

project success The amount of time and budget overrun of a project

quality of architecture The level of architecture (prescriptive notion) being consistent, complete, up-to-date and relevant

SAD see System Architecture Document

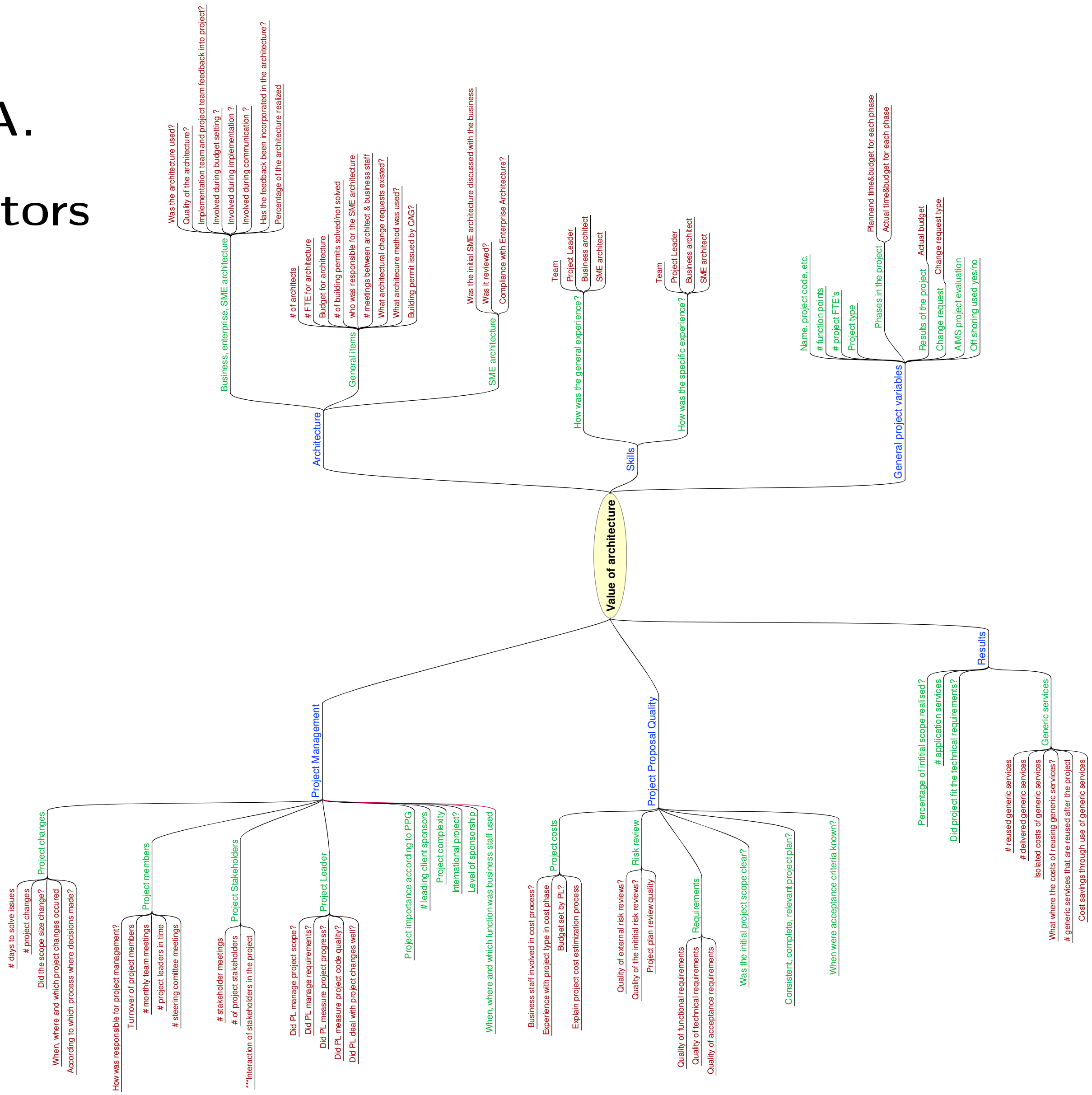
Six Sigma An organized and systematic method for strategic process improvement and new product and service development that relies on statistical methods and the scientific method to make dramatic reductions in customer defined defect rates

System Architecture Document A document that represents the blueprint of the project on implementation level

theoretical factors factors that are included in the AEM. These factors are not related to survey questions, but are added for other reasons

Index

Appendix A. Project factors



Appendix B.

Questionnaire

Questionnaire base

Identifier						Answer							
						Scale 1-6							
Question ID	Reply ID	All ID	Question	Answer Type	Statement	1. Complete disagree	2. Disagree	3. Disagree somewhat	4. Agree Somewhat	5. Agree	6. Completely Agree	Answer Column for Choice Budget Percentage Number	NVT = Niet van toepassing OB = Onbekend
369066	1	A.1	Involvement of the enterprise architect in setting the budget for the project	1-6	Enterprise architect was consulted and participated actively in the budget setting								
373207	2	A.1	Involvement of the business architect in setting the budget for the project	1-6	Business architect was consulted and participated actively in the budget setting								
397544	3	A.1 & Q.4	Involvement of the business staff in setting the budget for the project	1-6	Business staff was consulted and participated actively in the budget setting								
30308	4	A.10	How much of the planned domain architecture was realized?	Percentage									
991151	5	A.11	Was the business architecture complete, up-to-date, consistent and relevant?	1-6	The business architecture was very complete and consistent								
944232	9	A.12	Was the technical architecture complete, up-to-date, consistent and relevant?	1-6	The technical architecture was very complete and consistent								
83697	13	A.12	Was the Domain architecture complete and consistent?	1-6	The domain architecture was very complete and consistent								
222800	15	A.13	Which party was responsibility for architecture	choice	AAB, Outsourcing Partner, S, others								
848556	16	A.14	Involvement of the domain architect in the change process and decision-making process during FMI Phase	1-6	Domain architects was consulted and participated actively in the change process and decision-making process during FMI Phase								
849907	17	A.15	Involvement of the domain architect in setting the budget for the project	1-6	Domain architect was consulted and participated actively in the budget setting								
855288	18	A.16	To which extend was the business, and technical architecture reflected in the domain architecture?	1-6	The domain architecture reflected the technical and the business architecture fully								
678071	21	A.18	Were the BAD/SAD documents discussed with business	1-6	The BAD/SAD documents were fully discussed with the business								
313241	22	A.19	Were the BAD/SAD documents reviewed extensively and formally?	1-6	BAD/SAD documents were fully and formally reviewed								

Questionnaire 1/7

Figure B.1: *Questionnaire*

Questionnaire base

422555	23	A.2	Involvement of the enterprise architect in the change process and decision-making process during FMI Phase	1-6	Enterprise architect was consulted and participated actively in the change process and decision-making process during FMI Phase								
632448	24	A.2	Involvement of the business architect in the change process and decision-making process during FMI Phase	1-6	Business architect was consulted and participated actively in the change process and decision-making process during FMI Phase								
659281	25	A.20	Were there regular meetings between domain architect and business staff during FMI Phase	1-6	The domain architects did talk frequently to business staff during the FMI Phase								
730311	29	A.22	Actual man months used for architecture work	number									
910996	30	A.22	Estimated man months used for architecture work	number									
753605	31	A.23	Was CITA or another architecture method used	choice	CITA, IAF, TOGAF, others, none								
53700	32	A.24	Compliance of BAD/SAD documents to the technical architecture	1-6	The BAD/SAD documents were fully compliant to the technical architecture								
793556	33	A.24	Compliance of the BAD./SAD to the business architecture	1-6	The BAD/SAD documents were fully compliant to the business architecture								
991525	35	A.26	Was the CAG consulted?	choice	Yes - No								
650782	36	A.3	Did the enterprise architect meet regularly with the project team during FMI Phase?	1-6	Enterprise architect met often and regularly with the project team during FMI Phase								
128855	37	A.3	Did the business architect meet regularly with the project team during FMI Phase?	1-6	Business architects met often and regularly with the project team during FMI Phase								
906401	38	A.3	Did the domain architect meet regularly with the project team during FMI Phase?	1-6	Domain architects met often and regularly with the project team during FMI Phase								
998235	39	A.3	Did the business architect, enterprise architect and the domain architect meet regularly during FMI Phase?	choice	twice per week once per week twice per month once per month Less often								
796126	42	A.6	Number of consecutive business architects on the project	number									
743406	43	A.6	Number of consecutive enterprise architects on the project	number									
90480	44	A.6	Number of consecutive domain architects on the project	number									
734456	45	A.7	Was the feedback from implementation team incorporated in the technical architecture?	1-6	Findings during the project were evaluated and incorporated in the technical architecture								

Questionnaire 2/7

550924	46	A.7	Was the feedback from implementation team incorporated in the business architecture?	1-6	Findings during the project were evaluated and incorporated in the business architecture								
847978	47	A.8	Was the feedback from project team taken into account in the domain architecture?	1-6	Feedback from the implementation teams were taken into account in the domain architecture								
100385	48	A.9	Which percentage of the building permit issues were solved according to the directions of the building permit?	percentage									
329946	51	B.11	What percentage of the software was developed off-shore?	percentage									
903356	133	B.7	Building permit issued?	choice	Yes - No								
337599	146	M.1	Technical complexity of the project	1-6	The technical complexity of the project (number of systems touched, number of interfaces, number of databases, etc.) was very high								
154802	147	M.10	At what organizational level was the sponsorship of the project?	choice	VP, SVP, EVP, etc.								
915791	148	M.11	Number of team meetings per month	number									
163296	149	M.12	Were there any major changes in direction for the project? If, yes how many?	number									
174290	150	M.14	Did the scope size increase, stay the same or decrease ?	choice	increased sharply, increased, stayed the same, decreased decreased sharply								
621436	151	M.15	Is the project team located across multiple countries?	choice	1, 2, 3, 4, 5+								
726606	152	M.16	Number of Steering Committee meetings per quarter	number									
5578	155	M.19	Number of main stakeholder groups that are interested in the project	number									
43956	156	M.2	Amount of days it took, on average, to solve issues	number									
107810	158	M.21	Did the PM manage the changes to the project?	1-6	The PM manages changes very well								
439233	159	M.22	Did the PM manage and measure the quality of the code of the project?	1-6	The PM measured the quality of the code very well								
55194	160	M.23	Did the PM manage and measure the progress of the project? Which formal process were used?	1-6	The PM did measure the progress of the project very well								
661611	161	M.24	Did the PM manage the requirements?	1-6	Requirements were managed by the PM very well								
644920	162	M.25	Did the PM manage the scope of the project?	1-6	Scope of project was managed by the PM very well								

Questionnaire base

528023	163	M.26	Did the project implement a package from an external vendor	choice	No packages, 20% packages / 80% custom development 40% packages / 60% custom development 60% packages / 40% custom development 80% packages / 20% custom development Only packages								
738486	167	M.6	Were the architectural decisions made in a formal way?	1-6	Most of the architectural decisions were made formally								
648602	168	M.7	Amount of consecutive leading client sponsor (main sponsor of the project)	number									
959595	169	M.8	Amount of lead project managers (without the project managers for subprojects)	number									
342129	170	M.9	What was the main reason for this project?	choice	Legal requirements Strategic -long term Tactical- Medium term Operational - Short term								
413790	171	new	Estimated cost savings by reuse of generic services by other projects	budget									
581594	172	Q.1	How clear was the initial scope of the project?	1-6	The initial scope was really clear								
817076	174	Q.2	How clear were the initial functional requirements/specifications	1-6	The initial functional requirements/specification were very clear								
859027	175	Q.20	How clear were the acceptance requirements	1-6	The acceptance requirements were very clear								
486132	176	Q.21	When were the acceptance criteria known? At the start of the project, in the middle, or only at the end	choice	start of the project, in the middle, at the end								
47703	177	Q.3	How clear were the technical requirements	1-6	The technical requirements were very clear								
903922	179	Q.6	Full review of the project proposal: peer review, risk management review, legal review, sales review and delivery review.	1-6	Review of project proposal was done extensively								
22144	180	Q.7	Quality of the process for setting the initial project budget	1-6	The process of defining the project budget was of very high quality								
516226	181	Q.8	Was the project proposal complete, consistent and relevant	1-6	Was the project proposal complete, consistent and relevant								
25699	185	R.1	The isolated, specific development cost of the generic services	budget									
388401	186	R.10	Was there a possibility to build services generic, which weren't build that way?	1-6	There was no possibility to build more generic services								

Questionnaire 4/7

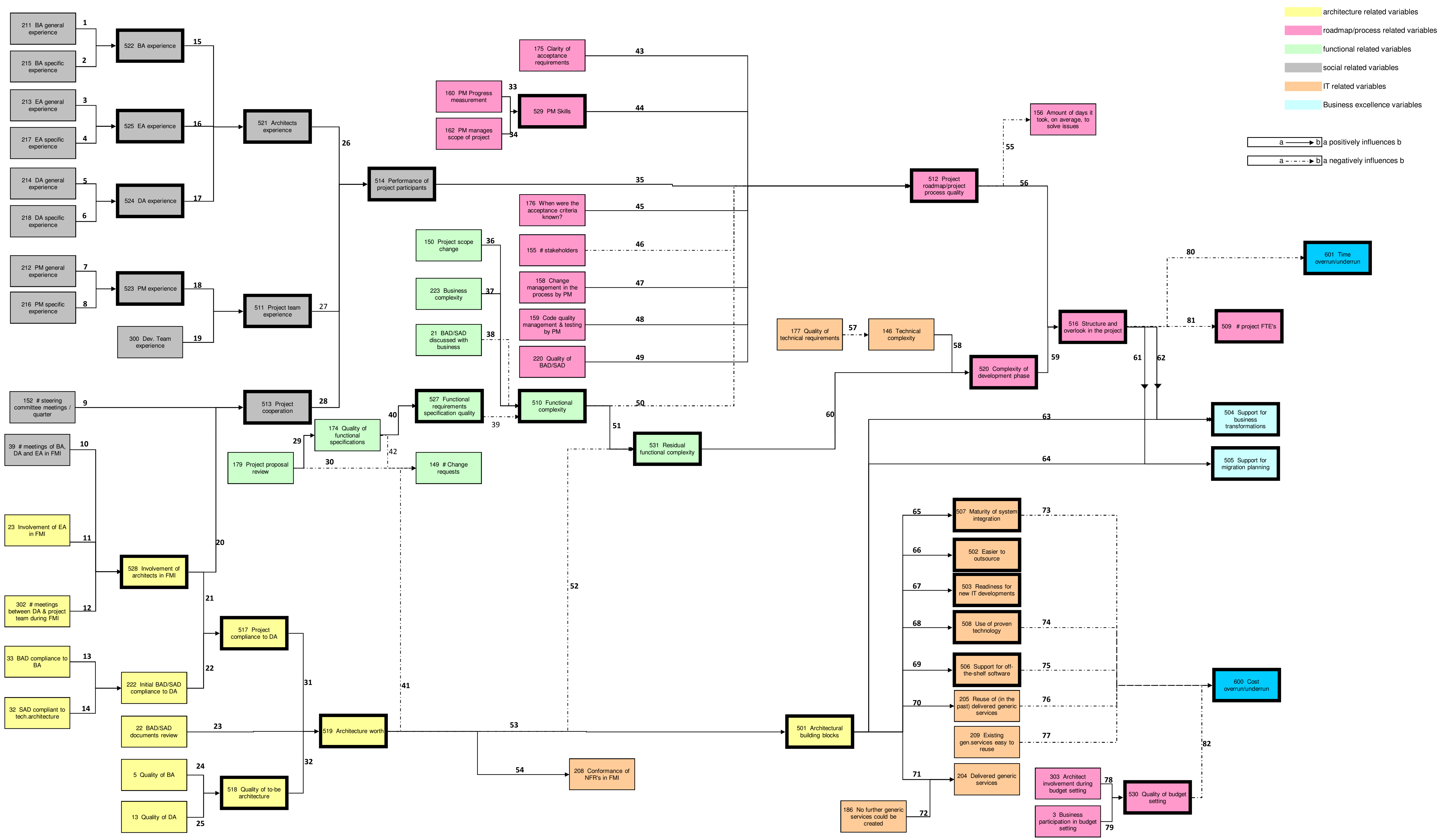
550930	188	R.13	Increase/decrease awareness of architecture because of the project	choice	increased sharply, increased, stayed the same, decreased decreased sharply
686822	189	R.14	Did the project increase/descrease the Alignment of the domain with business architecture	choice	increased sharply, increased, stayed the same, decreased decreased sharply
731150	190	R.15	How is the domain aligned currently with the business architecture	1-6	The domain is now fully aligned with the business architecture
949596	191	R.16	Did the project increase/descrease the Alignment of the domain with technical architecture	choice	increased sharply, increased, stayed the same, decreased decreased sharply
137594	192	R.17	Alignment of the domain currently with technical architecture	'1-6	The domain is now fully aligned with the technical architecture
950571	195	R.2	The savings of the project because of the reuse of generic (previously build) services	budget	
232948	196	R.20	Did the business value increase, stay the same or decrease because of Architecture?	choice	increased sharply, increased, stayed the same, decreased decreased sharply
128564	197	R.21	Types of business value	choice	Business value increased by higher revenues Business value increased because of cost savings Business value increased by customer intimacy Business value dit not increase Business value decreased
491755	198	R.22	The operational cost in the domain	choice	increased sharply, increased, stayed the same, decreased decreased sharply
625174	199	R.23	Continuity in the domain	choice	increased sharply, increased, stayed the same, decreased decreased sharply

Questionnaire base

720078	200	R.24	Security risks in the domain	choice	increased sharply, increased, stayed the same, decreased decreased sharply								
159448	201	R.25	Complexity in the domain	choice	increased sharply, increased, stayed the same, decreased decreased sharply								
641514	202	R.26	Lower cost (per project) for future projects in the domain because of the project	1-6	The potential cost for future projects decreased considerably								
235071	203	R.3	Number of application (non-generic) services delivered by the project	number									
551004	204	R.4	Number of generic services delivered by the project	number									
129742	205	R.5	Number of generic services reused by the project	number									
457032	206	R.6	Percentatge of delivered functionality	choice	>100% 100-90% 90-80% 80-60% 50-20% <20%								
873019	207	R.7	Are the generic services of the project actually reused by other projects	1-6	The delivered generic services are used by other projects								
716090	208	R.8	Conformance of the delivered non-functional requirements, such as response time, security, availability, etc, to the non-functional requirements from the PRL.	choice	>100% 100-90% 90-80% 80-60% 50-20% <20%								
25435	209	R.9	Was it easy to reuse existing generic services for the project?	1-6	Existing generic services were very easy to reuse								
990520	210	S.1	Broad general experience of the development team	1-6	The development team had extensive general experience								
363848	211	S.2	Broad general experience of the business architect	1-6	The business architect had extensive general experience								
486562	212	S.3	Broad general experience of the project manager	1-6	The PM had extensive general experience								
232770	213	S.4	Broad general experience of the enterprise architect	1-6	The enterprise architect had extensive general experience								
281296	214	S.4	Broad general experience of the domain architect	1-6	The domain architect had extensive general experience								

Questionnaire 6/7

161623	215	S.5	Specific experience of the business architect	1-6	The business architect had extensive specific experience with the subject of the project								
884502	216	S.6	Specific experience of the project manager	1-6	The PM had much specific experience with the subject of the project								
323033	217	S.7	Specific experience of the enterprise architect	1-6	The enterprise architect had much specific experience with the subject of the project								
109917	218	S.7	Specific experience of the domain architect	1-6	The domain architect had extensive specific experience								
714899	219	S.8	Specific experience of the development team	1-6	The development team had extensive specific experience with the subject of the project								
973458	220		Were the BAD/SAD documents complete and consistent?	1-6	Were the BAD/SAD documents complete and consistent?								
247202	222		Compliance of the BAD./SAD to the domain architecture	1-6	The BAD/SAD documents followed fully the domain architecture								
778772	223		Business complexity of the project	1-6	The business complexity of the project (translating requirements into functionality) was very high								
345495	224		Please quantify any major changes in the design, because of architecture, which changed ithe project cost significantly? (Plus is increased, minus is decreased)	number									
33218	225		Did architecture cause major changes in the design which increased/decreased the project cost significantly?	choice	increased sharply, increased, stayed the same, decreased decreased sharply								
932345	230		What was the business value of the functional requirements as described by the business?	1-6	The business value of the functional requirements as described by the business was very high								
320953	231		Was there a pre-documented business architecture in the start of the project?	1-6	There was a clear pre-documented business architecture in the start of the project								


architecture related variables
roadmap/process related variables
functional related variables
social related variables
IT related variables
Business excellence variables
a → b a positively influences b
a -·-·→ b a negatively influences b
211 BA general experience
215 BA specific experience
213 EA general experience
217 EA specific experience
214 DA general experience
218 DA specific experience
212 PM general experience
216 PM specific experience
522 BA experience
525 EA experience
524 DA experience
523 PM experience
300 Dev. Team experience
521 Architects experience
511 Project team experience
514 Performance of project participants
152 # steering committee meetings / quarter
513 Project cooperation
39 # meetings of BA, DA and EA in FMI
23 Involvement of EA in FMI
302 # meetings between DA & project team during FMI
528 Involvement of architects in FMI
33 BAD compliance to BA
32 SAD compliant to tech.architecture
222 Initial BAD/SAD compliance to DA
517 Project compliance to DA
22 BAD/SAD documents review
519 Architecture worth
5 Quality of BA
13 Quality of DA
518 Quality of to-be architecture
208 Conformance of NFR's in FMI
179 Project proposal review
174 Quality of functional specifications
527 Functional requirements specification quality
149 # Change requests
150 Project scope change
223 Business complexity
21 BAD/SAD discussed with business
175 Clarity of acceptance requirements
160 PM Progress measurement
162 PM manages scope of project
529 PM Skills
176 When were the acceptance criteria known?
155 # stakeholders
158 Change management in the process by PM
159 Code quality management & testing by PM
220 Quality of BAD/SAD
510 Functional complexity
531 Residual functional complexity
512 Project roadmap/project process quality
156 Amount of days it took, on average, to solve issues
177 Quality of technical requirements
146 Technical complexity
520 Complexity of development phase
516 Structure and overlook in the project
509 # project FTE's
601 Time overrun/underrun
504 Support for business transformations
505 Support for migration planning
501 Architectural building blocks
507 Maturity of system integration
502 Easier to outsource
503 Readiness for new IT developments
508 Use of proven technology
506 Support for off-the-shelf software
205 Reuse of (in the past) delivered generic services
209 Existing gen.services easy to reuse
204 Delivered generic services
186 No further generic services could be created
303 Architect involvement during budget setting
3 Business participation in budget setting
530 Quality of budget setting
600 Cost overrun/underrun

Appendix D.
Additional factors

Table D.1: *Additional factors and their value calculation*

Factor ID	Factor name	Meaning	Value calculation
501	Architectural building blocks	Level of developing through standardized building blocks (both business and IT)	519
502	Easier to outsource	Maturity level for outsourcing	501
503	Readiness for new IT developments	Level of readiness for new IT developments	501
504	Support for business transformations	Level of support for business transformations (is the business agile?)	$501 + 516$
505	Support for migration planning	Level of support of migration planning (is IT and business agile?)	$501 + 516$
506	Support for of-the-shelf software	Level of easiness to implement of-the-shelf (standardized) software	501
507	Maturity of system integration	Level of (IT) system integration within the enterprise	501
508	Use of proven technology	Suitability level of implementation of proven technology	501
509	# project FTE's	FTE (Full Time Equivalent, equals the amount of hours in one workweek)	-516
510	Functional complexity	Level of functional complexity; how difficult was the functional aspect of the deliverable (was it clear what to construct, was the functional design discussed with business)	$-150 + 223 - 21 - 527$
511	Project team experience	Summarizes the experience of the PM and the development team	$523 + 300$

Factor ID	Factor name	Meaning	Value calculation
512	Project roadmap / process quality	Level of complexity in the *process* of coming to a deliverable. How many stakeholders were involved? Was it clear what to deliver? What was the functional complexity?	$175 + 529 + 514 + 176 - 155 + 158 + 159 + 220 - 510$
513	Project cooperation	Level of cooperation in the project. Includes the number of meetings of steering group and the involvement of architects in FMI phase	$152 + 528$
514	Project participants	What was the total quality of the people in the project? This includes the cooperation of the people in the project as well as their experience.	$521 + 511 + 513$
516	Structure and overlook in the project	Represents the structure and overlook in the both the process executing the project (the project roadmap) as well as in the development phase. This factor is important because it is considered as an important influence for the time overrun.	$512 - 520$
517	Project compliance to DA	Level of compliance of realized project architecture with DA	$528 + 222$
518	Quality of to-be architecture	Level of quality (how relevant is the architecture) of the to-be architecture (DA and BA)	$5 + 13$
519	Architecture worth	Represent the worth of architecture in the project, which is considered to consist of the quality of, compliance to DA and the BAD/SAD review	$517 + 22 + 518$
520	Complexity of development phase	Level of complexity in the development phase	$146 + 531$
521	Architects experience	Total architects experience	$522 + 525 + 524$
522	BA experience	Total BA experience	$211 + 215$
523	PM experience	Total PM experience	$212 + 216$
524	DA experience	Total DA experience	$214 + 218$
525	EA experience	Total EA experience	$213 + 217$

Factor ID	Factor name	Meaning	Value calculation
527	Requirements specification quality	Level of quality of requirements specification	174
528	Involvement of architects in FMI	Level of involvement of architects in FMI phase (determined by the number of meetings in FMI phase)	$39 + 23 + 302$
529	PM Skills	Level of skills of PM in performing his tasks (management of progress and scope)	$160 + 162$
530	Quality of budget setting	Level of quality of budget setting. Strongly influences the budget setting and, as such, budget overrun	$303 + 3$
531	Residual functional complexity	Level of functional complexity that is left after the influence of architecture. This factor is based on the assumption that architecture reduces the functional complexity. The level of functional complexity that is left after this reduction is represented by this factor. In order to not end with a negative number, 510 is multiplied by 2	$2 * 510 - 519$
600	Cost overrun/underrun	Percentage of budget overrun/underrun, overrun being positive	N/A
601	Time overrun/underrun	Percentage of time overrun/underrun, overrun being positive	N/A

Appendix E.

Relations in the AEM

Table E.1: *Relations from the AEM and their description*

Relation ID	Description
1	BA experience includes BA general experience
2	BA experience includes BA specific experience
3	EA experience includes EA general experience
4	EA experience includes EA specific experience
5	DA experience includes DA general experience
6	DA experience includes DA specific experience
7	PM experience includes PM general experience
8	PM experience includes PM specific experience
9	# steering committee meetings influences project cooperation
10	# meeting of BA, DA, EA meetings in FMI influences involvements of architects in FMI
11	Involvement of EA in FMI influences involvements of architects in FMI
12	# meetings between DA and project team in FMI influences involvement of architects in FMI
13	BAD compliance to BA influences initial BAD/SAD compliance to DA
14	If SAD is compliant to tech. architecture, the initial BAD/SAD compliance to DA is high
15	BA experience influences architects experience
16	EA experience influences architects experience
17	DA experience influences architects experience
18	PM experience influences project team experience
19	Development team experience influences project team experience
20	Involvements of architects in FMI phase influences project team cooperation

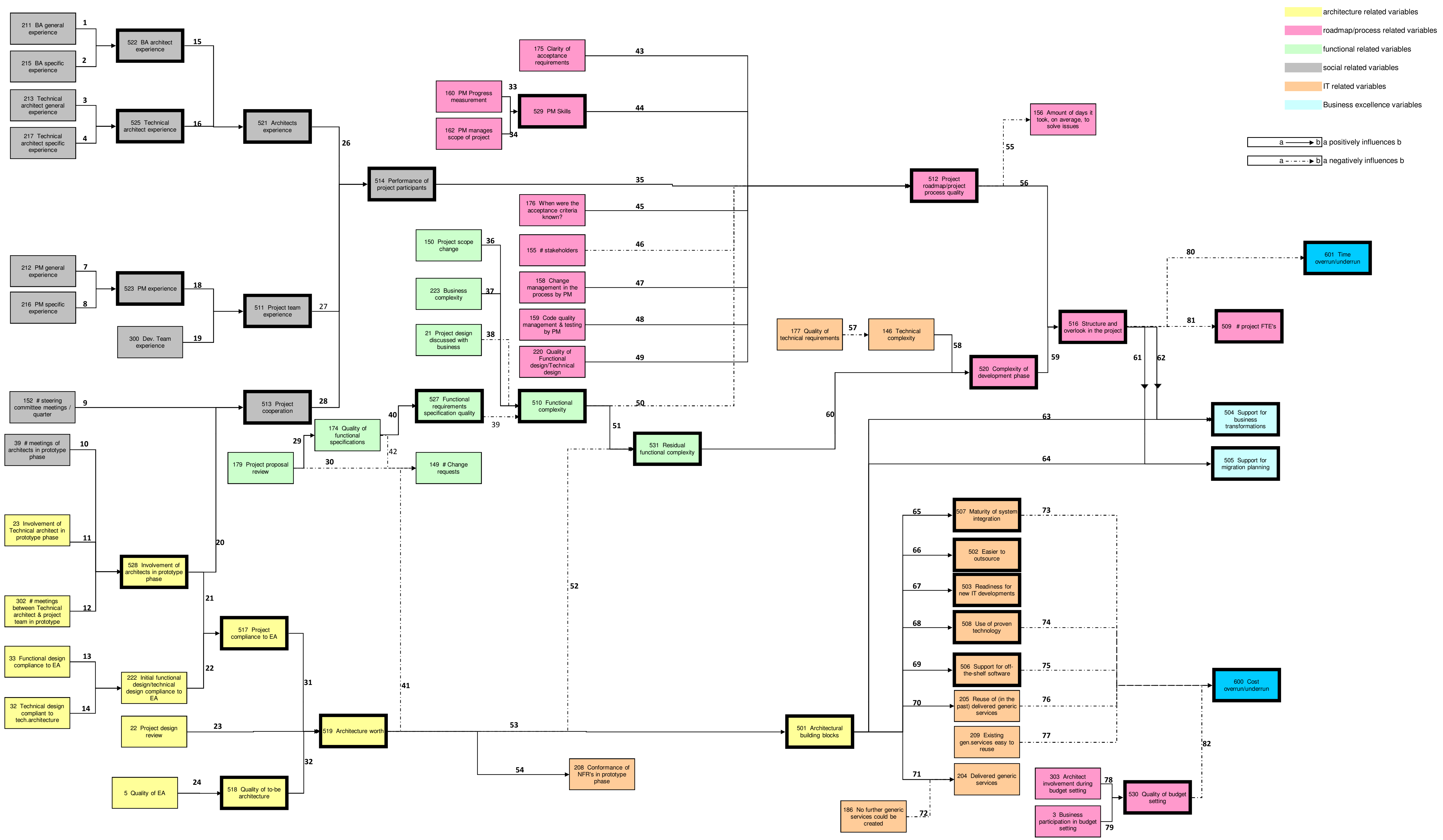
Relation ID	Description
21	Involvements of architects in FMI influences project compliance to DA because the architects focus on the compliance of the project to the DA
22	If the initial BAD/SAD is compliant to DA, the project compliance to DA will be higher
23	The review of the BAD/SAD documents will influence the worth of architecture on the project (if these documents are not reviewed extensively, the focus on architecture is less)
24	Quality of BA influences quality of the to-be architecture (to-be architecture consists of BA and DA)
25	Quality of DA influences quality of the to-be architecture
26	Architects experience influences performance of project participants
27	Project team experience influences performance of project participants
28	Project cooperation influences performance of project participants
29	Review of project proposal influences quality of the functional specifications. Assumed is that little review on the project proposal results in low quality functional specifications
30	Review of project proposal influences number of change requests (little review on the project proposal can lead to more change requests later in the project)
31	Compliance of the project to the DA influences the worth of architecture
32	Quality of the to-be architecture influences the worth of architecture
33	Progress measurement of the PM influences PM skills
34	Scope management of the PM influences PM skills
35	Performance of the project participants influences the *process* in the project, the project roadmap quality
36	Project scope change influences the functional complexity
37	Business complexity influences the functional complexity
38	Discussion of BAD/SAD with business influences the functional complexity (little discussion leads to higher functional complexity)
39	Quality of functional requirements influences functional complexity (when the quality of the functional requirements is low, the functional complexity is higher)

Relation ID	Description
40	Quality of functional specifications has the same value as functional requirements specification quality
41	Architecture influences the number of change requests
42	Higher quality of function specifications leads to less change requests
43	Clarity of acceptance requirements influences project roadmap quality
44	The skills of the PM are crucial in managing the project roadmap
45	When the acceptance criteria are known late in the project, the quality of the project process is harder to maintain
46	When more stakeholders are involved in the project, the quality of the project process is harder to maintain
47	Change management is crucial for the quality of the project process
48	Code quality measurement and testing are crucial for the quality of the project process
49	Low BAD/SAD quality influences the project process. In this situation it would not be very clear what has to be designed/created.
50	The functional complexity is very important for the project process. When the functional complexity is low, it is easier to maintain a high project process quality
51	Functional complexity influences the functional complexity that is left after the influence of architecture. This functional complexity is the complexity that is decisive in the process of the project
52	This relation indicates a conditional relation: the use of architecture influences the functional complexity by reducing it (this is an assumption in the use of architecture). This link is based on the assumption that architecture reduces the functional complexity.
53	The higher worth of architecture, the building blocks are defined in both business components and IT components
54	The higher worth of architecture, the more likely the NFR's will be conform the specifications in the project proposal
55	The higher quality in the project process (considering the data where factor 512 consists of), the easier it is to solve issues
56	A high level of project process quality influences the level of structure and overlook in the project

Relation ID	Description
57	The quality of technical requirements influences the technical complexity. Low quality of technical requirements leads to higher technical complexity (it is not clear what to produce)
58	Technical complexity influences the complexity of the development phase (because in the development phase, the focus is on meetings the technical requirements).
59	Complexity of the development phase influences the structure and overlook in the project
60	The development phase consists of both the technical complexity and the functional complexity (which could be reduced through architecture)
61	Structure and overlook in the project influences support for migration planning because projects are easier to change since their project process has higher quality
62	Structure and overlook in the project will ease business transformations
63	Worth of architecture influences the support for business transformations because the architectural building blocks ease the business transformations (more standardization of business enables the transformation)
64	Worth of architecture influences the support for migration planning because architectural building blocks facilitate the business transformations (more standardization of business enables the transformation)
65-69	See Section 6.2.3.
70	An architecture that specifies the need for architectural building blocks facilitates the reuse of delivered generic services
71	An architecture that specifies the need for architectural building blocks facilitates delivering generic services
72	Not being able to produce more existing services influences the delivered generic services
73	Higher system integration leads to cost reduction
74	Use of proven technology leads to cost reduction
75	Use of off the shelf software leads to cost reduction
76	Reusing pre-developed services lead to cost reduction
77	When existing generic services are easy to reuse, this will lead to cost reduction

Relation ID	**Description**
78	Architects involvement in budget setting leads to higher quality of budget setting
79	Business involvement in budget setting leads to higher quality of budget setting
80	Structure and overlook in the project influence time overrun/underrun
81	Structure and overlook in the project influences # project FTE's
82	Quality of the budget setting influences cost overrun/underrun

Appendix F. Architecture Effectiveness Model (generic)



Appendix G.

Questionnaire histograms

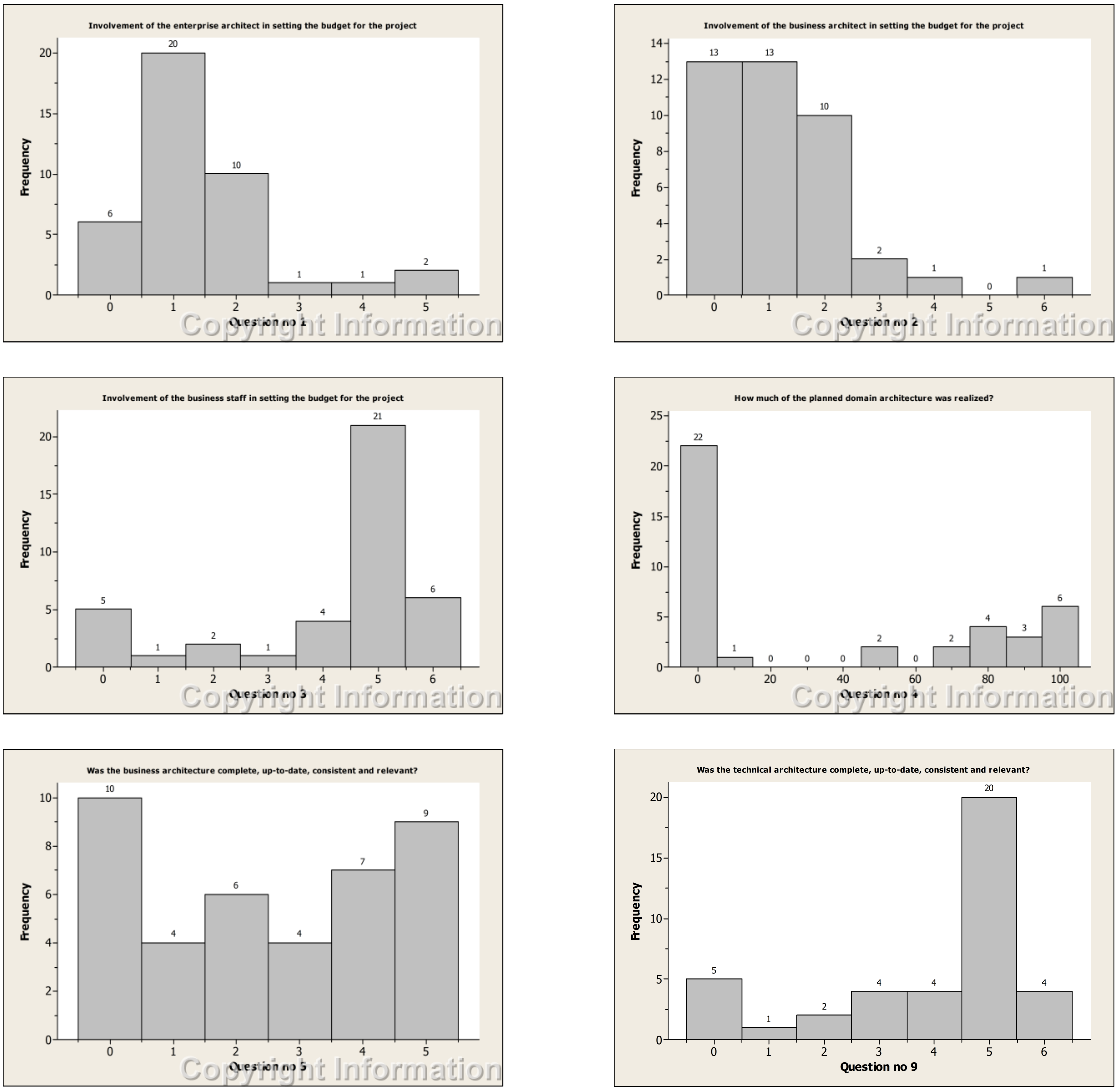
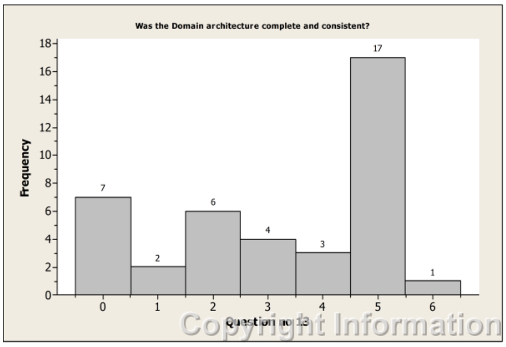
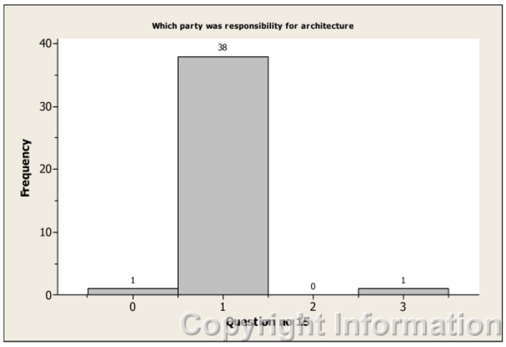
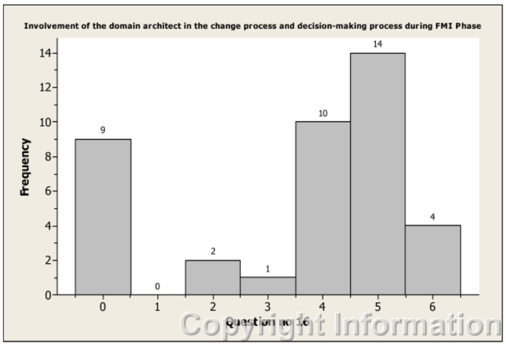
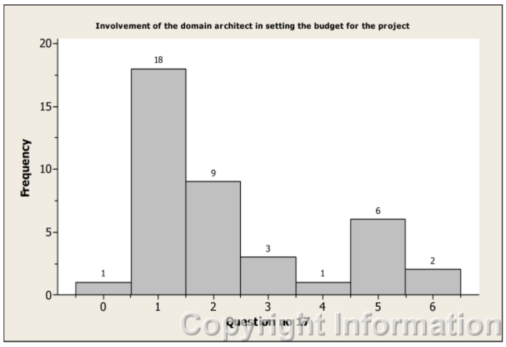


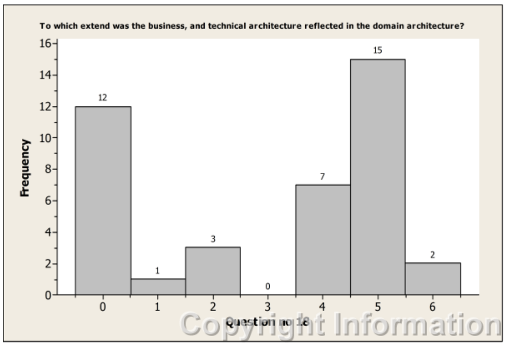
Figure G.1: *Histograms of questionnaire answers*

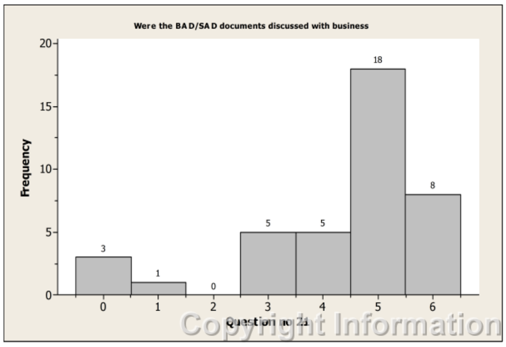

Was the Domain architecture complete and consistent?
Frequency
Question no 13
Copyright Information

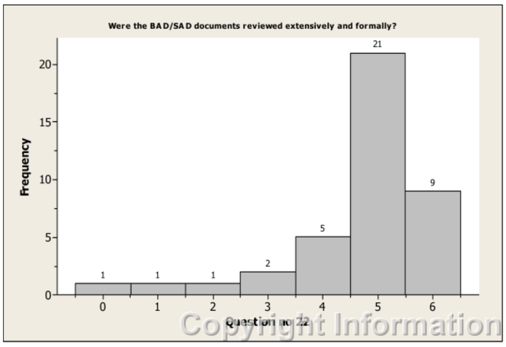

Which party was responsibility for architecture
Frequency
Question no 15
Copyright Information

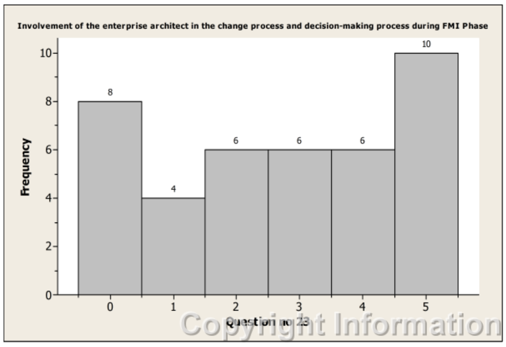

Involvement of the domain architect in the change process and decision-making process during FMI Phase
Frequency
Question no 16
Copyright Information

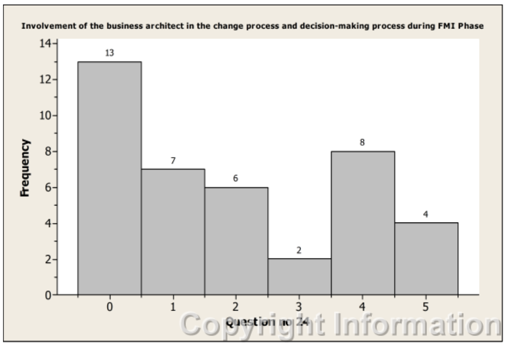

Involvement of the domain architect in setting the budget for the project
Frequency
Question no 17
Copyright Information

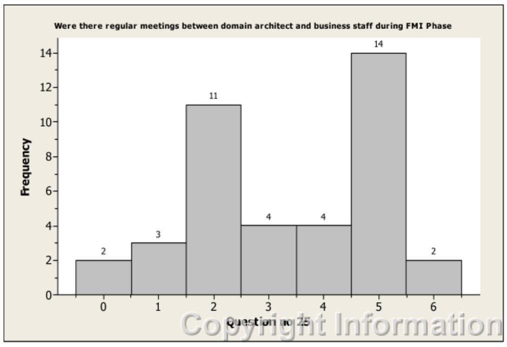

To which extend was the business, and technical architecture reflected in the domain architecture?
Frequency
Question no 18
Copyright Information

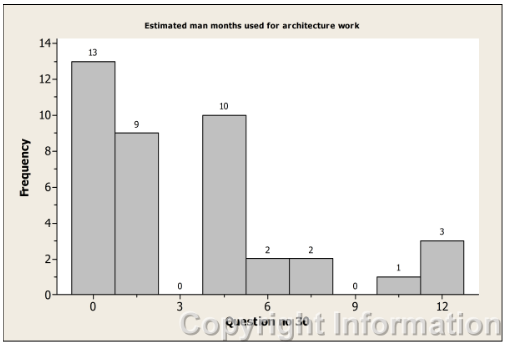

Were the BAD/SAD documents discussed with business
Frequency
Question no 21
Copyright Information

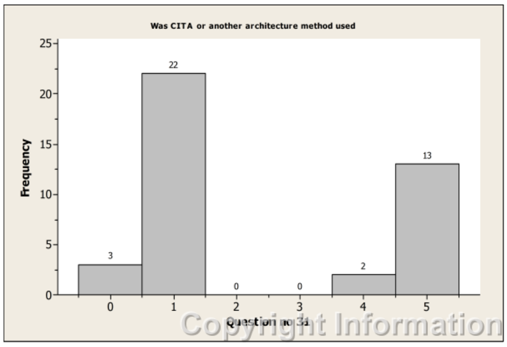

Were the BAD/SAD documents reviewed extensively and formally?
Frequency
Question no 22
Copyright Information

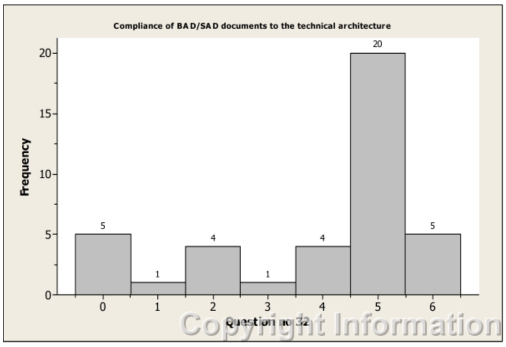

Involvement of the enterprise architect in the change process and decision-making process during FMI Phase
Frequency
Question no 23
Copyright Information

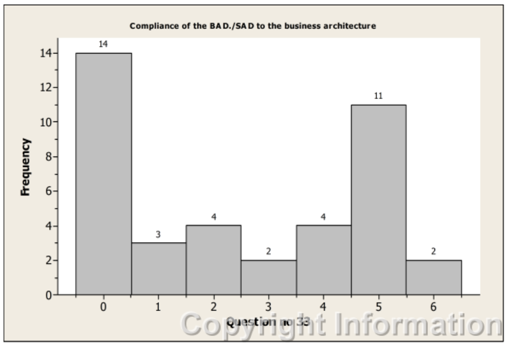

Involvement of the business architect in the change process and decision-making process during FMI Phase
Frequency
Question no 24

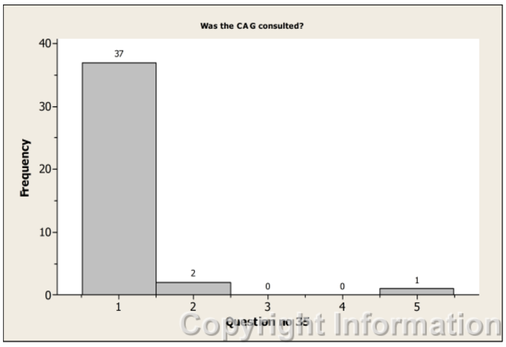

Were there regular meetings between domain architect and business staff during FMI Phase
Frequency
Question no 25

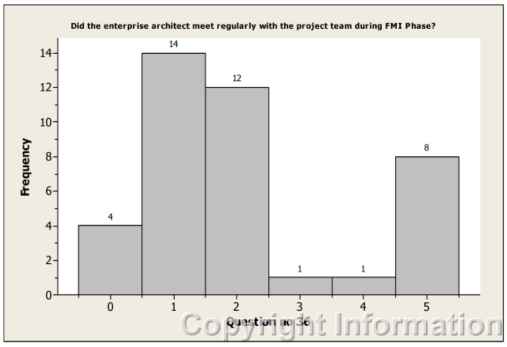

Estimated man months used for architecture work
Frequency
Question no 30

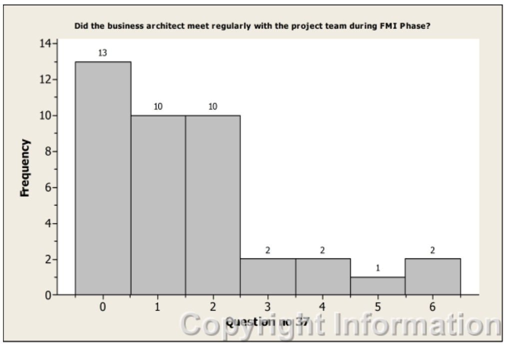

Was CITA or another architecture method used
Frequency
Question no 31

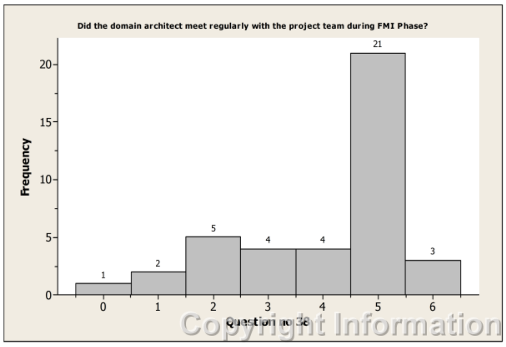

Compliance of BAD/SAD documents to the technical architecture
Frequency
Question no 32

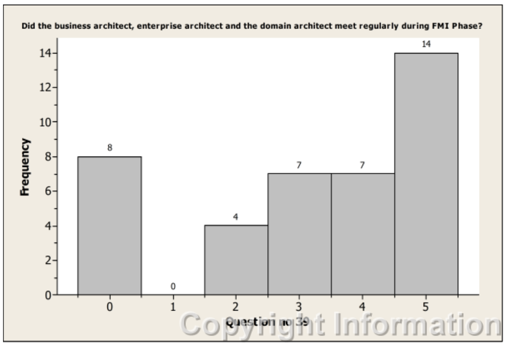

Compliance of the BAD./SAD to the business architecture
Frequency
Question no 33

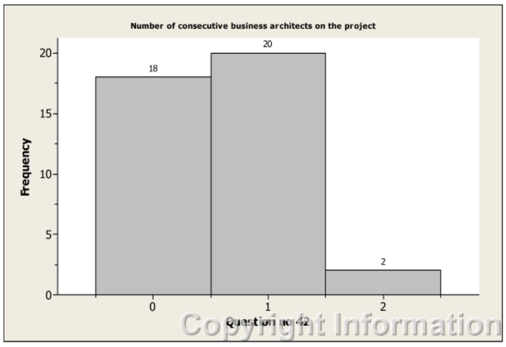

Was the CAG consulted?
Frequency
Question no 35

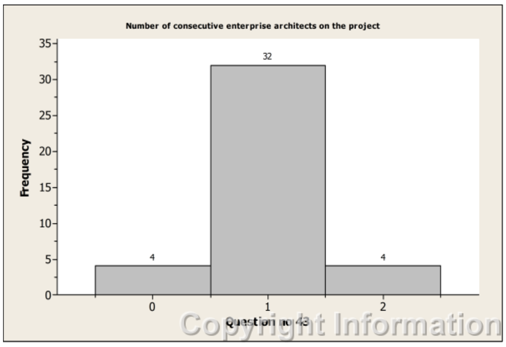

Did the enterprise architect meet regularly with the project team during FMI Phase?
Frequency
Question no 36

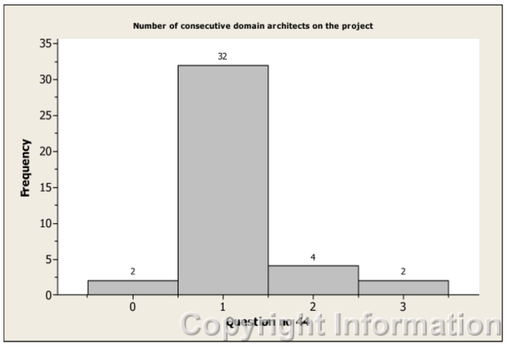

Did the business architect meet regularly with the project team during FMI Phase?
Frequency
Question no 37
Copyright Information

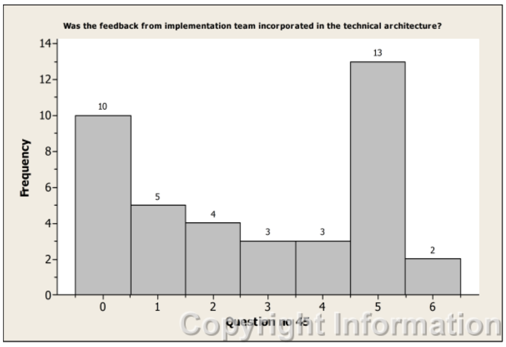

Did the domain architect meet regularly with the project team during FMI Phase?
Frequency
Question no 38
Copyright Information

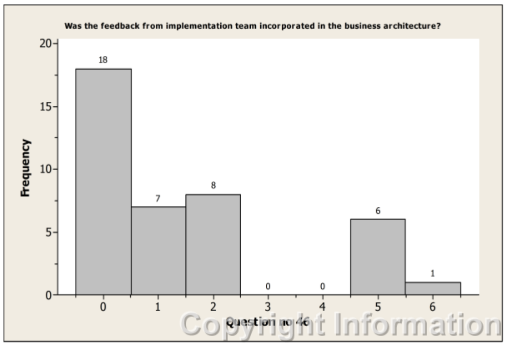

Did the business architect, enterprise architect and the domain architect meet regularly during FMI Phase?
Frequency
Question no 39
Copyright Information

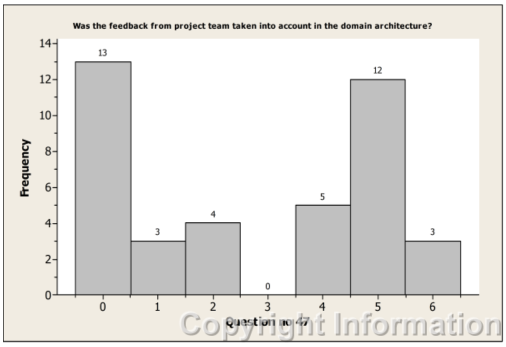

Number of consecutive business architects on the project
Frequency
Question no 42
Copyright Information

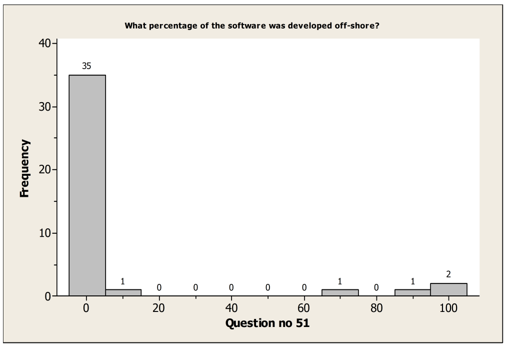

Number of consecutive enterprise architects on the project
Frequency
Question no 43
Copyright Information

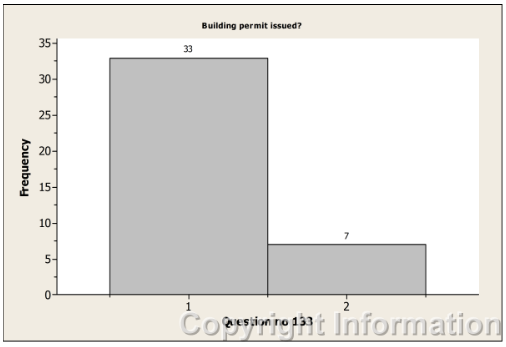

Number of consecutive domain architects on the project
Frequency
Question no 44
Copyright Information

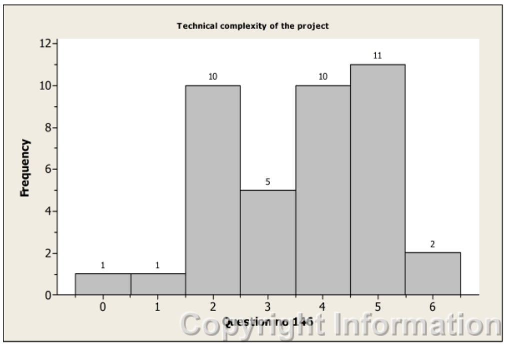

Was the feedback from implementation team incorporated in the technical architecture?
Frequency
Question no 45
Copyright Information

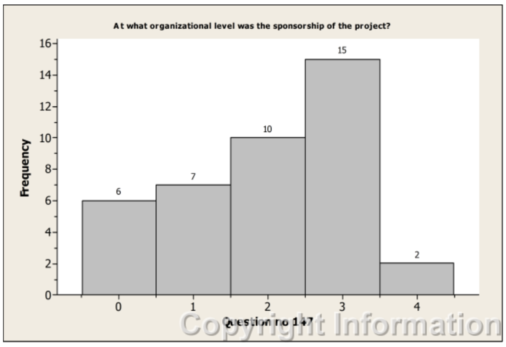

Was the feedback from implementation team incorporated in the business architecture?
Frequency
Question no 46
Copyright Information

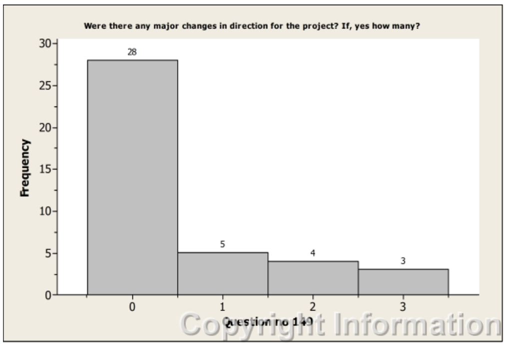

Was the feedback from project team taken into account in the domain architecture?
Frequency
Question no 47
Copyright Information

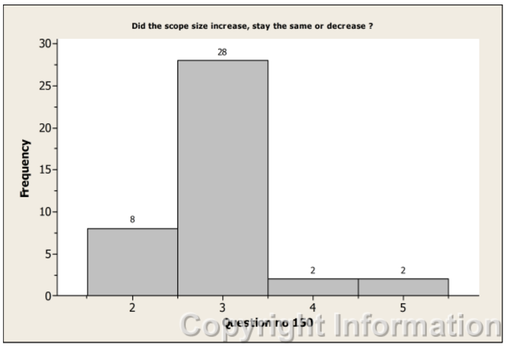

What percentage of the software was developed off-shore?
Frequency
Question no 51

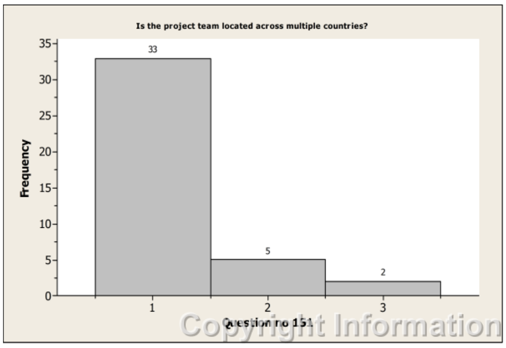

Building permit issued?
Frequency
Question no 133
Copyright Information

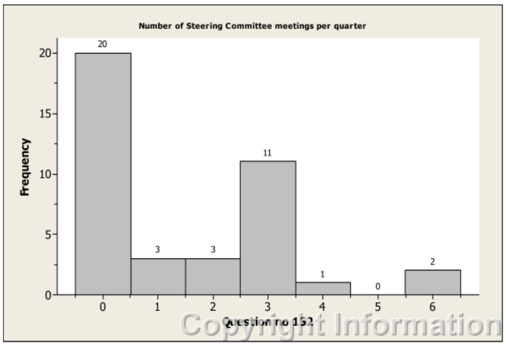

Technical complexity of the project
Frequency
Question no 146
Copyright Information

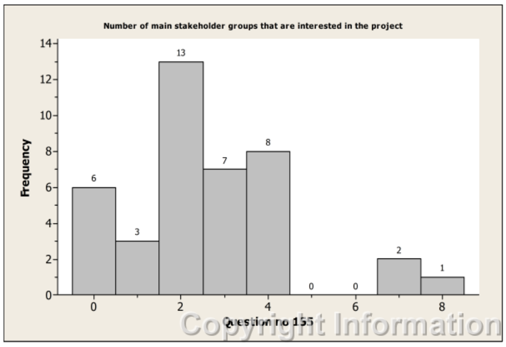

At what organizational level was the sponsorship of the project?
Frequency
Question no 147
Copyright Information

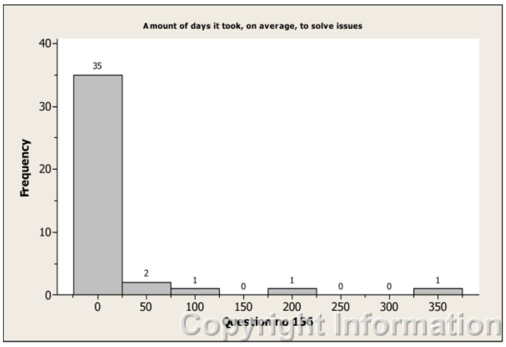

Were there any major changes in direction for the project? If, yes how many?
Frequency
Question no 149
Copyright Information

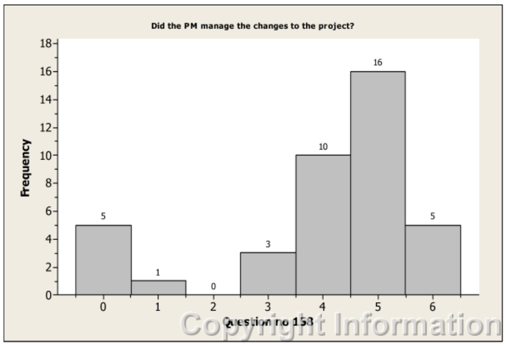

Did the scope size increase, stay the same or decrease ?
Frequency
Question no 150
Copyright Information

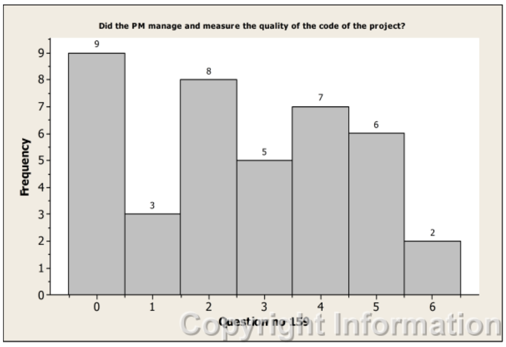

Is the project team located across multiple countries?
Frequency
Question no 151
Copyright Information

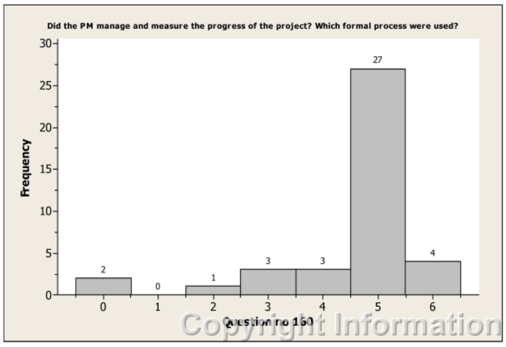

Number of Steering Committee meetings per quarter
Frequency
Question no 152

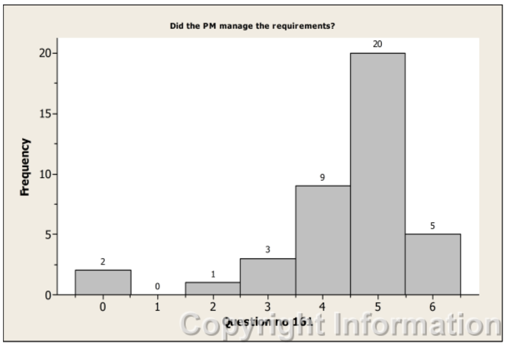

Number of main stakeholder groups that are interested in the project
Frequency
Question no 155

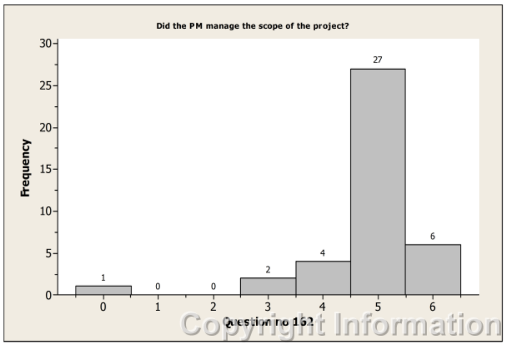

Amount of days it took, on average, to solve issues
Frequency
Question no 156

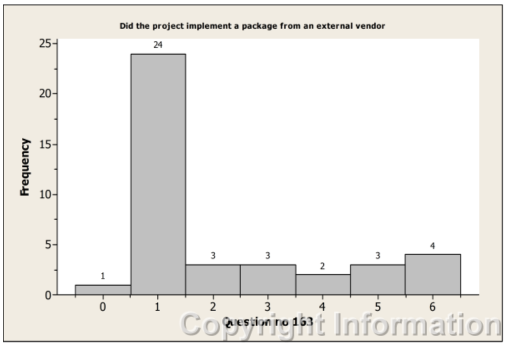

Did the PM manage the changes to the project?
Frequency
Question no 158

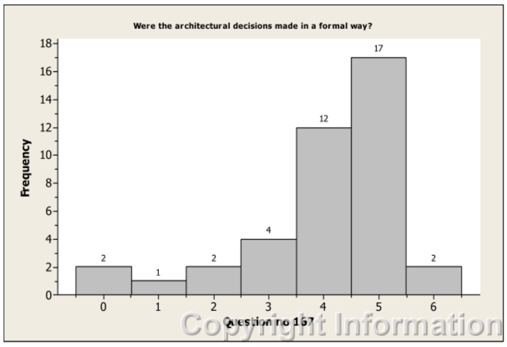

Did the PM manage and measure the quality of the code of the project?
Frequency
Question no 159

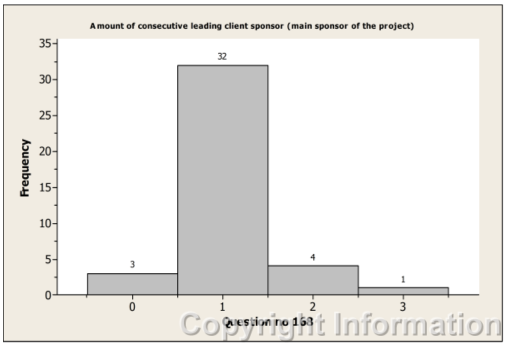

Did the PM manage and measure the progress of the project? Which formal process were used?
Frequency
Question no 160

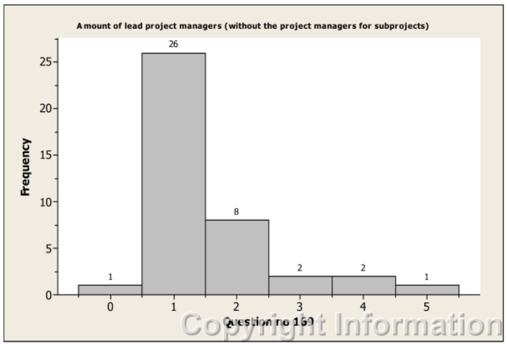

Did the PM manage the requirements?
Frequency
Question no 161

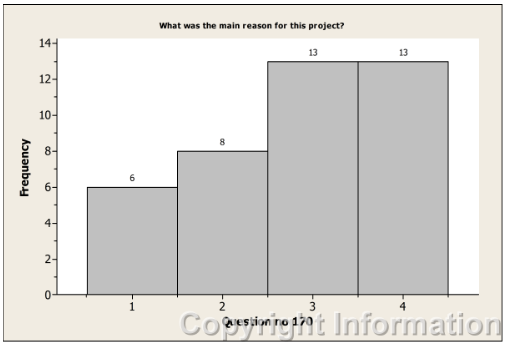

Did the PM manage the scope of the project?
Frequency
Question no 162

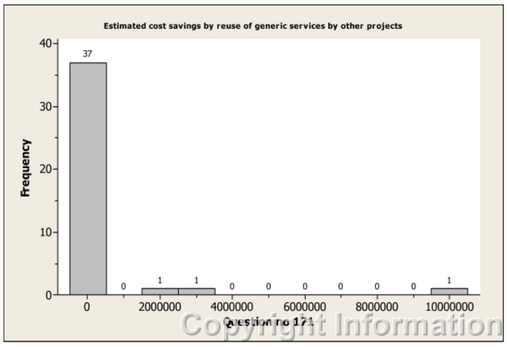

Did the project implement a package from an external vendor
Frequency
Question no 163
Copyright Information

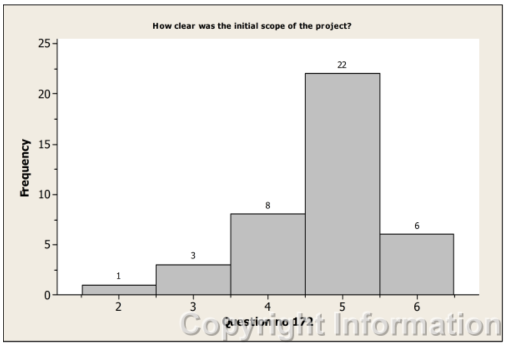

Were the architectural decisions made in a formal way?
Frequency
Question no 167
Copyright Information

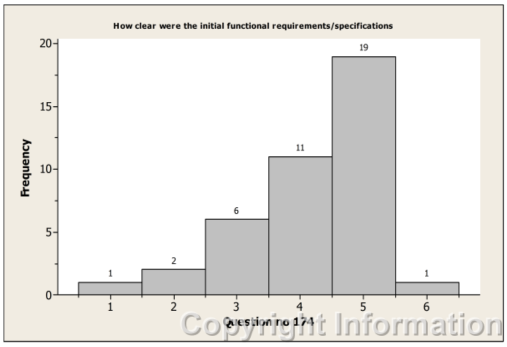

Amount of consecutive leading client sponsor (main sponsor of the project)
Frequency
Question no 168
Copyright Information

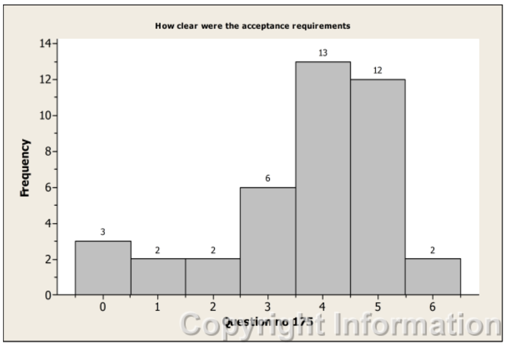

Amount of lead project managers (without the project managers for subprojects)
Frequency
Question no 169
Copyright Information

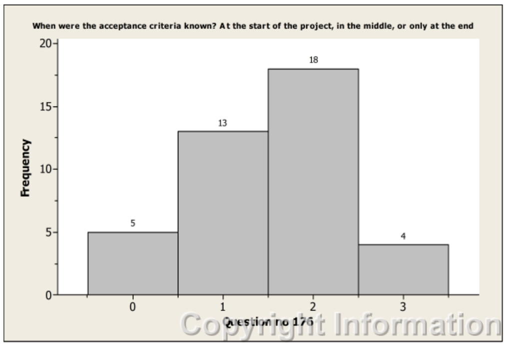

What was the main reason for this project?
Frequency
Question no 170
Copyright Information

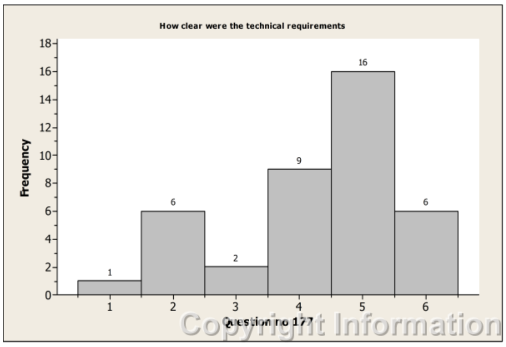

Estimated cost savings by reuse of generic services by other projects
Frequency
Question no 171
Copyright Information

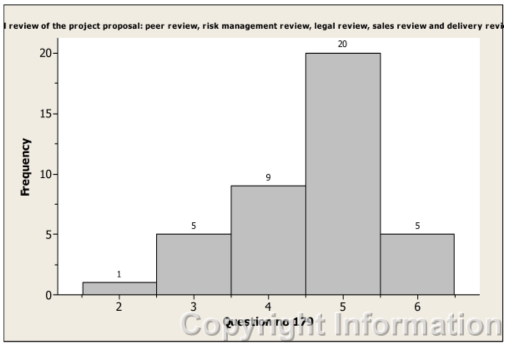

How clear was the initial scope of the project?
Frequency
Question no 172
Copyright Information

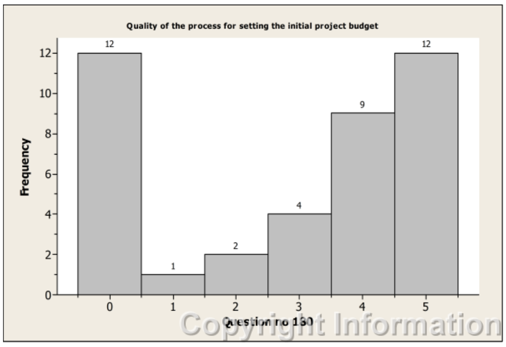

How clear were the initial functional requirements/specifications
Frequency
Question no 174
Copyright Information

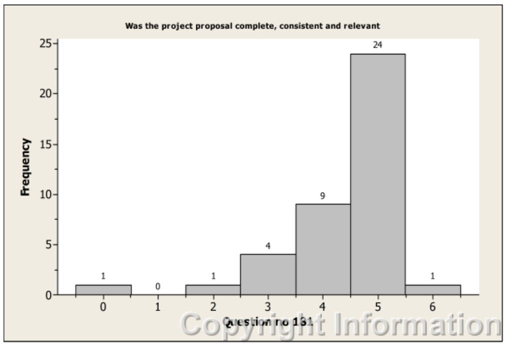

How clear were the acceptance requirements
Frequency
Question no 175
Copyright Information

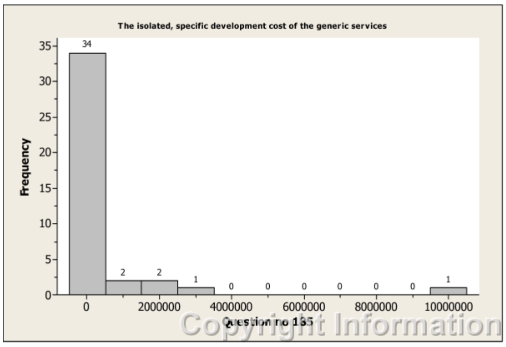

When were the acceptance criteria known? At the start of the project, in the middle, or only at the end
Frequency
Question no 176
Copyright Information

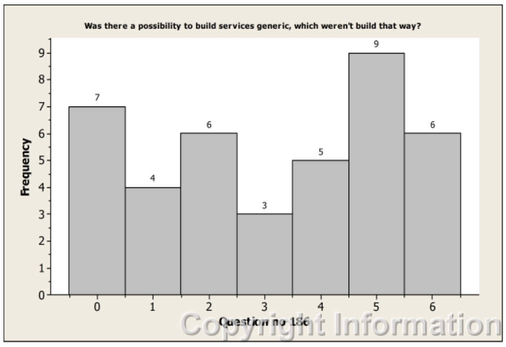

How clear were the technical requirements
Frequency
Question no 177
Copyright Information

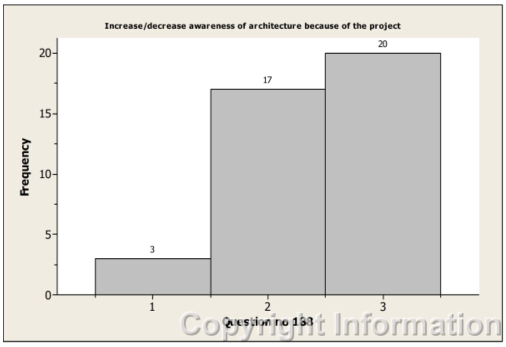

l review of the project proposal: peer review, risk management review, legal review, sales review and delivery revi
Frequency
Question no 179
Copyright Information

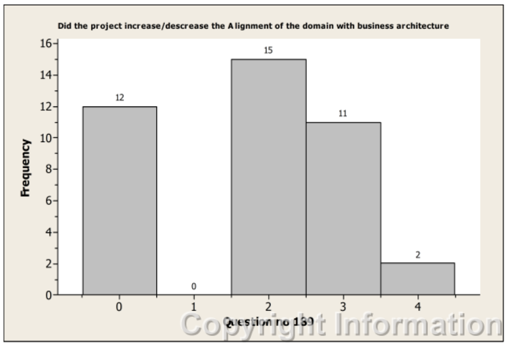

Quality of the process for setting the initial project budget
Frequency
Question no 180
Copyright Information

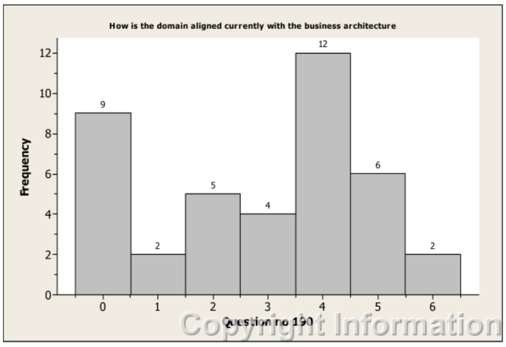

Was the project proposal complete, consistent and relevant
Frequency
Question no 181
Copyright Information

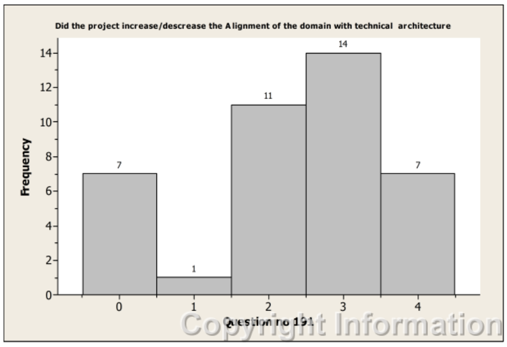

The isolated, specific development cost of the generic services
Frequency
Question no 185
Copyright Information

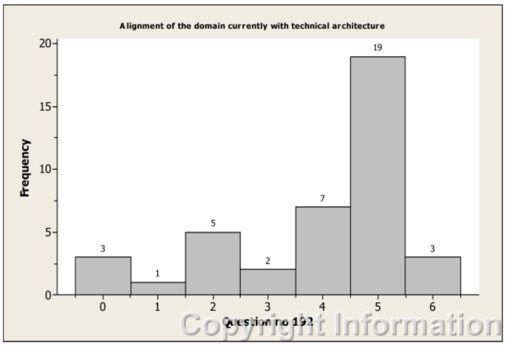

Was there a possibility to build services generic, which weren't build that way?
Frequency
Question no 186
Copyright Information

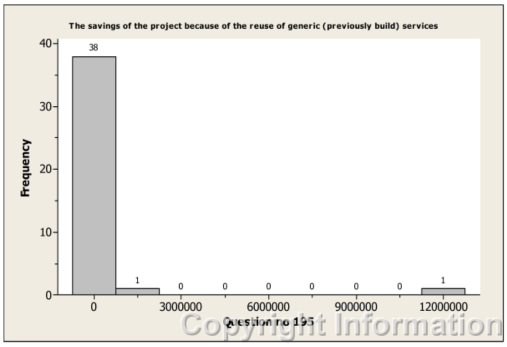

Increase/decrease awareness of architecture because of the project
Frequency
Question no 188
Copyright Information

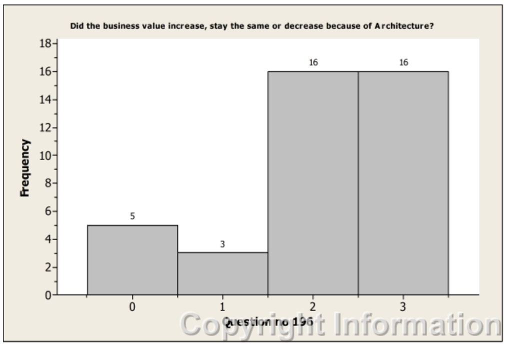

Did the project increase/descrease the Alignment of the domain with business architecture
Frequency
Question no 189
Copyright Information

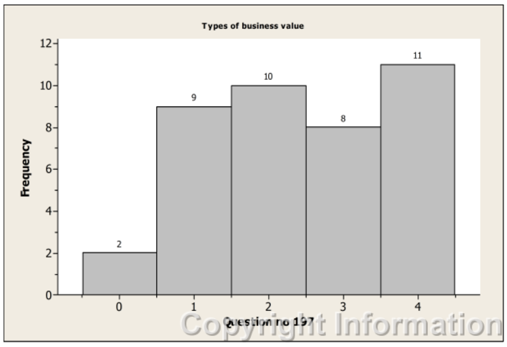

How is the domain aligned currently with the business architecture
Frequency
Question no 190
Copyright Information

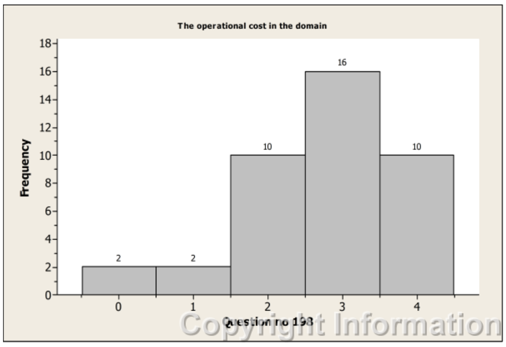

Did the project increase/descrease the Alignment of the domain with technical architecture
Frequency
Question no 191
Copyright Information

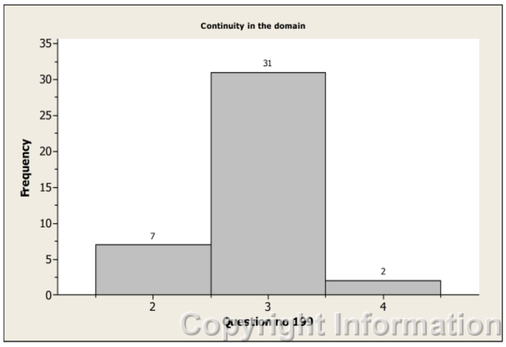

Alignment of the domain currently with technical architecture
Frequency
Question no 192
Copyright Information

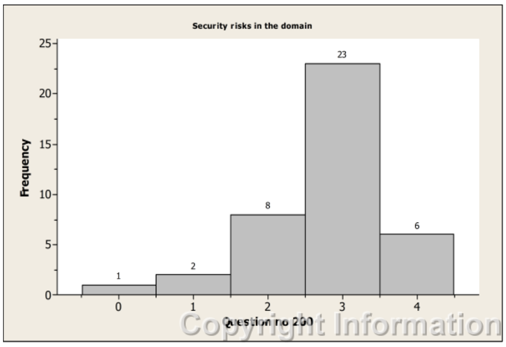

The savings of the project because of the reuse of generic (previously build) services
Frequency
Question no 195
Copyright Information

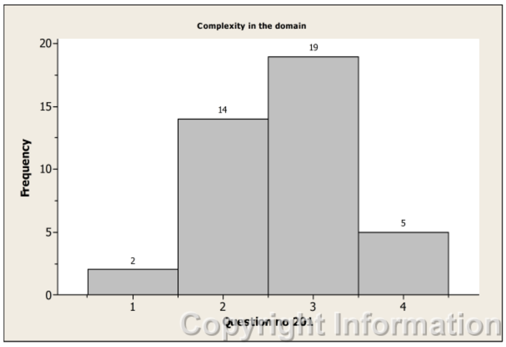

Did the business value increase, stay the same or decrease because of Architecture?
Frequency
Question no 196
Copyright Information

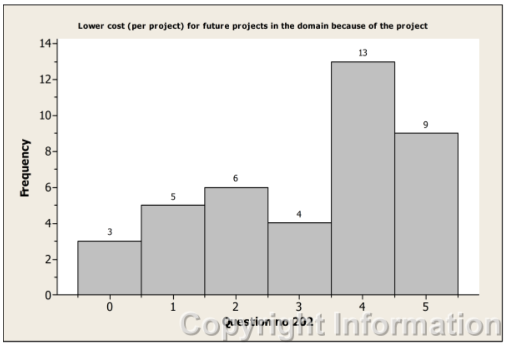

Types of business value
Frequency
Question no 197
Copyright Information

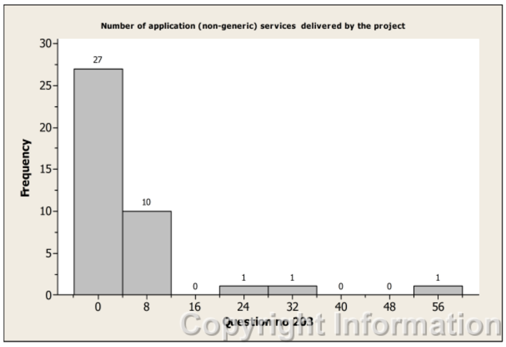

The operational cost in the domain
Frequency
2 2 10 16 10
Question no 198
Copyright Information

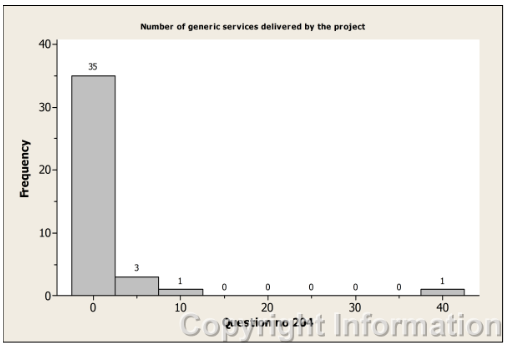

Continuity in the domain
Frequency
7 31 2
Question no 199
Copyright Information

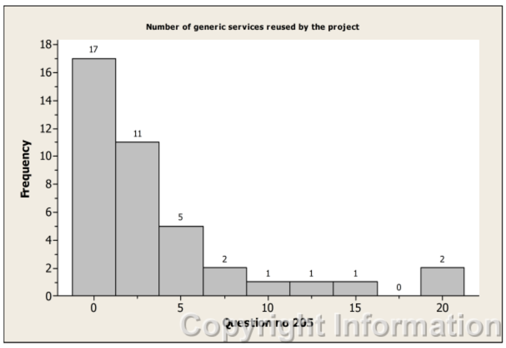

Security risks in the domain
Frequency
1 2 8 23 6
Question no 200
Copyright Information

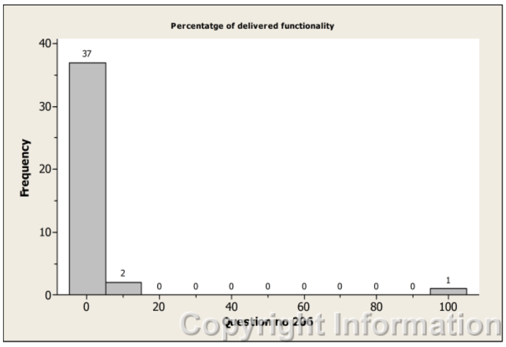

Complexity in the domain
Frequency
2 14 19 5
Question no 201
Copyright Information

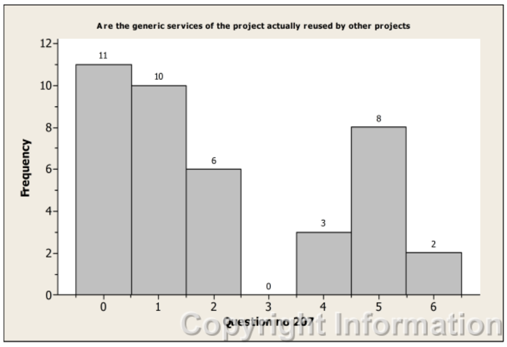

Lower cost (per project) for future projects in the domain because of the project
Frequency
3 5 6 4 13 9
Question no 202
Copyright Information

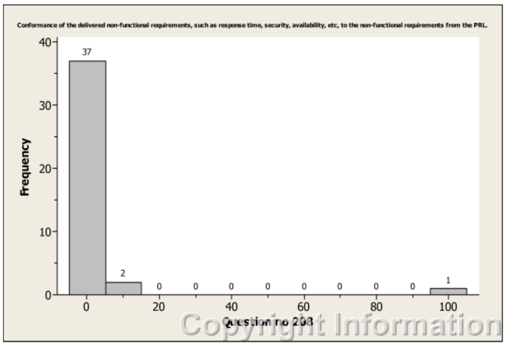

Number of application (non-generic) services delivered by the project
Frequency
27 10 0 1 1 0 0 1
Question no 203
Copyright Information

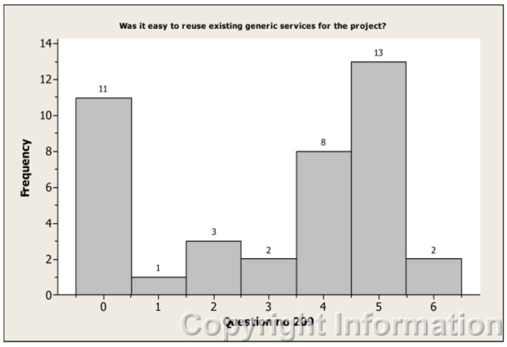

Number of generic services delivered by the project
Frequency
35 3 1 0 0 0 0 0 1
Question no 204
Copyright Information

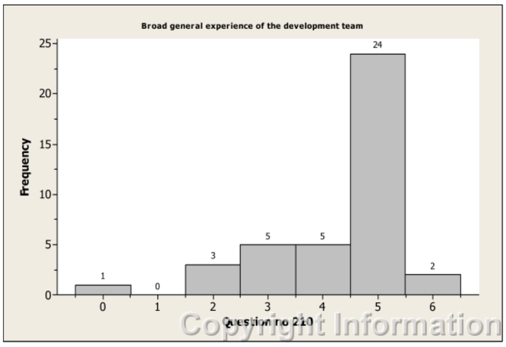

Number of generic services reused by the project
Frequency
17 11 5 2 1 1 1 0 2
Question no 205
Copyright Information

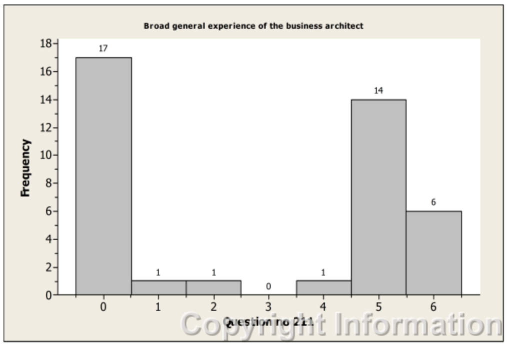

Percentatge of delivered functionality
Frequency
Question no 206

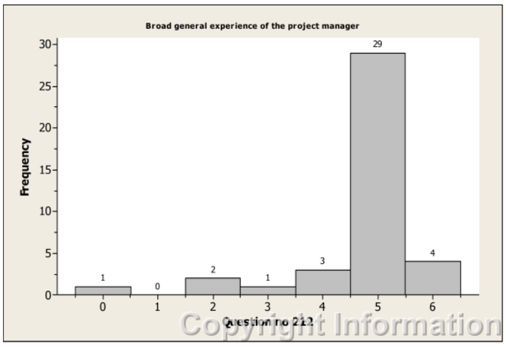

Are the generic services of the project actually reused by other projects
Frequency
Question no 207

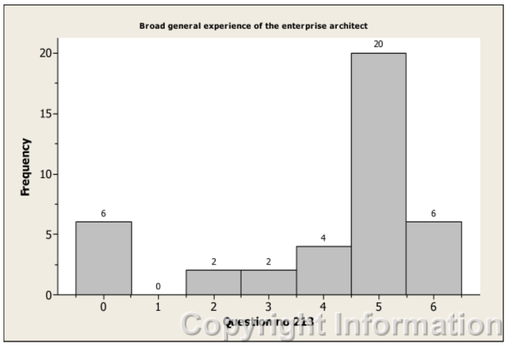

Conformance of the delivered non-functional requirements, such as response time, security, availability, etc, to the non-functional requirements from the PRL.
Frequency
Question no 208

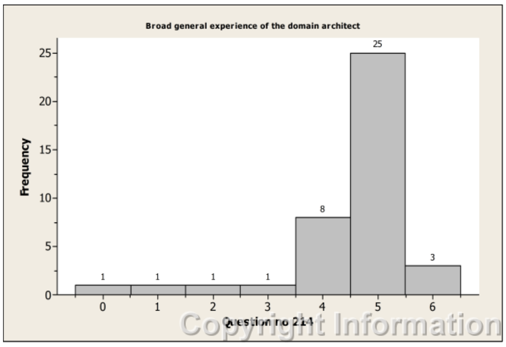

Was it easy to reuse existing generic services for the project?
Frequency
Question no 209

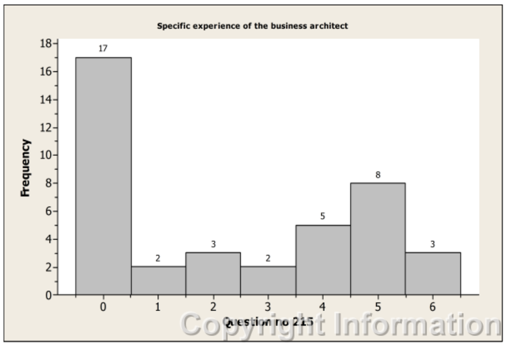

Broad general experience of the development team
Frequency
Question no 210


Broad general experience of the business architect
Frequency
Question no 211

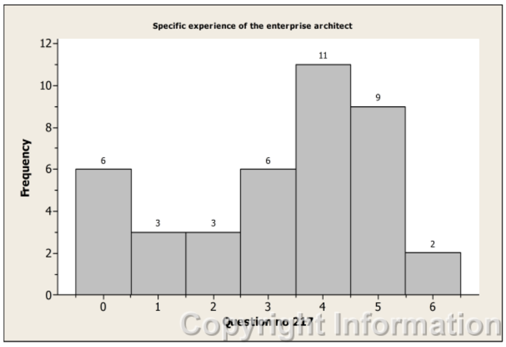

Broad general experience of the project manager
Frequency
Question no 212

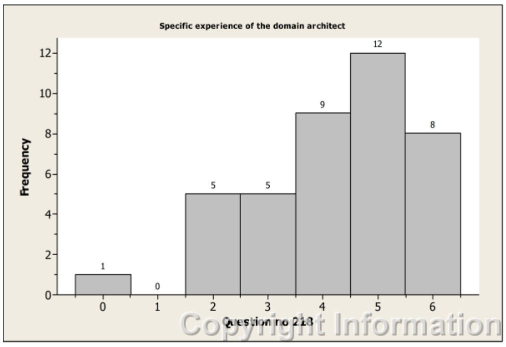

Broad general experience of the enterprise architect
Frequency
Question no 213

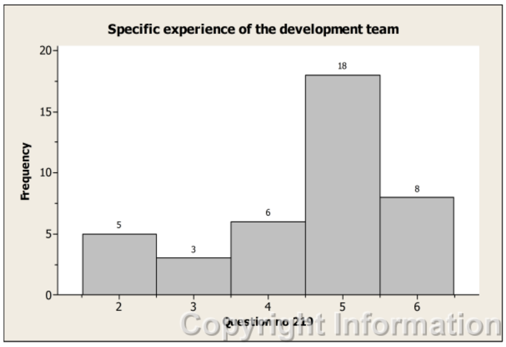

Broad general experience of the domain architect
Frequency
1 1 1 1 8 25 3
0 1 2 3 4 5 6
Question no 214
Copyright Information

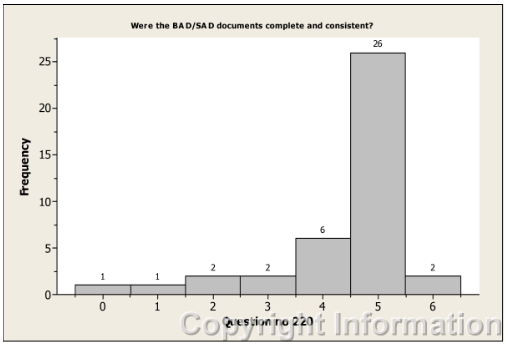

Specific experience of the business architect
Frequency
17 2 3 2 5 8 3
0 1 2 3 4 5 6
Question no 215
Copyright Information

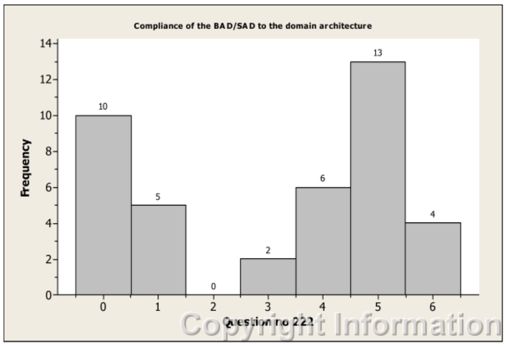

Specific experience of the project manager
Frequency
3 7 1 8 18 3
1 2 3 4 5 6
Question no 216
Copyright Information

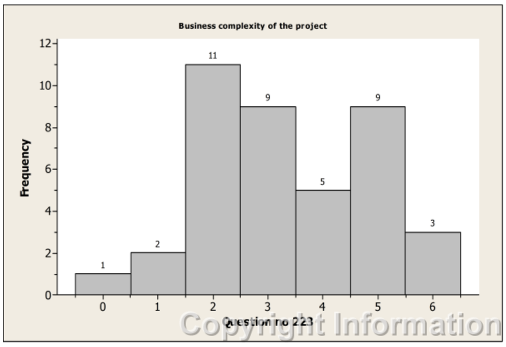

Specific experience of the enterprise architect
Frequency
6 3 3 6 11 9 2
0 1 2 3 4 5 6
Question no 217
Copyright Information

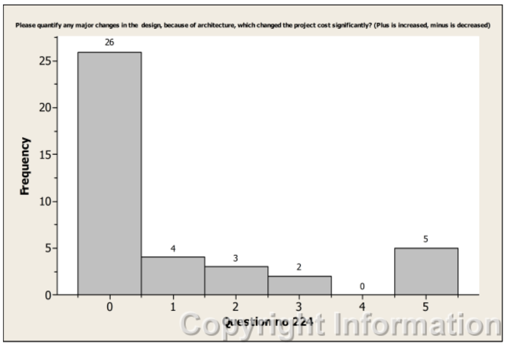

Specific experience of the domain architect
Frequency
1 0 5 5 9 12 8
0 1 2 3 4 5 6
Question no 218
Copyright Information

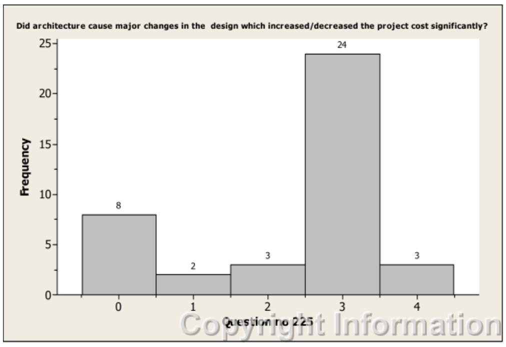

Specific experience of the development team
Frequency
5 3 6 18 8
2 3 4 5 6
Question no 219
Copyright Information

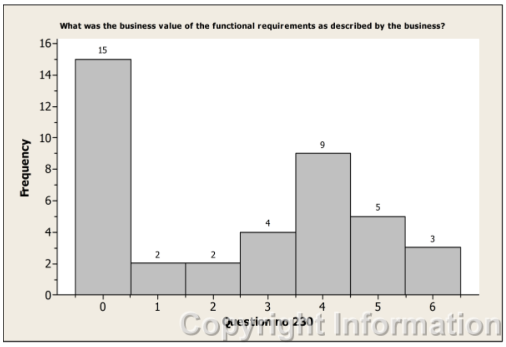

Were the BAD/SAD documents complete and consistent?
Frequency
1 1 2 2 6 26 2
0 1 2 3 4 5 6
Question no 220
Copyright Information

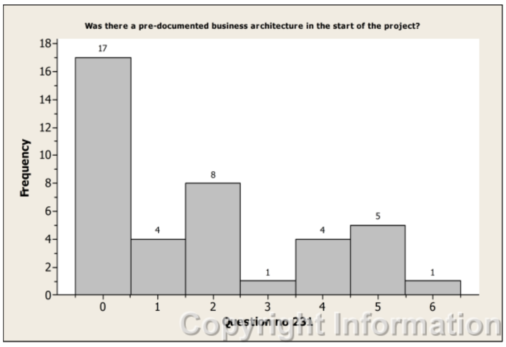

Compliance of the BAD/SAD to the domain architecture
Frequency
10 5 0 2 6 13 4
0 1 2 3 4 5 6
Question no 222
Copyright Information


Business complexity of the project
Frequency
Question no 223
Copyright Information


Please quantify any major changes in the design, because of architecture, which changed the project cost significantly? (Plus is increased, minus is decreased)
Frequency
Question no 224
Copyright Information


Did architecture cause major changes in the design which increased/decreased the project cost significantly?
Frequency
Question no 225
Copyright Information


What was the business value of the functional requirements as described by the business?
Frequency
Question no 230
Copyright Information


Was there a pre-documented business architecture in the start of the project?
Frequency
Question no 231
Copyright Information

ID	Q A	Q B	Corr %	Corr Reason	Decision	Decision Reason	Comments
1	5	9	77,58		Leave as is		
2	5	13	79,18		Leave as is		
3	1	17	79,47	DA was sometimes EA	Delete 1 & 17 => Add 303	DA & EA are TA	
4	5	18	78,61	Strange question	Delete 18		
5	13	18	84,78	TA & BA <==> Complete DA	Delete 18	TA & BA <==> Complete DA	
6	2	24	79,89	Makes sense	Leave as is		
7	16	25	79,44	A lot of communication in FMI	Delete 16 & 25 => Add 302	16 is cause of 25	
8	4	33	89,63		Leave as is		
9	1	36	77,05	Coincidence?	Leave as is		
10	16	38	86,03	A lot of communication in FMI	Delete 16 & 38 => Add 302	16 is cause of 38	
11	22	47	81,13	Coincidence?	Delete 45 & 47 => Add 301		
12	4	202	80,25	Realized DA influences future costs	Leave as is	4 is cause of 202	
13	9	211	77,62	Coincidence?	Leave as is	Makes no sense	
14	5	214	77,31	Coincidence?	Leave as is		
15	21	220	78,74	Makes sense	Leave as is		
16	4	222	80,02		Leave as is		
17	22	222	80,24	BAD/SAD is set up according to existing architecture	Leave as is		
18	21	230	77,08	Business value combines with discussion of bad/sad with business	Leave as is		
19	5	231	79,37	Makes sense	Leave as is		
20	30	203	82,91	Question misinterpreted by interviewees (e.g. 58 ser)	Leave as is	Both are interesting outcomes	
21	37	204	79,8	Makes no sense	Leave as is		
22	30	205	79,69	Use of generic services is correlated with estimated Atime	Leave as is	Different outcomes for 30	
23	30	207	78,51		Leave as is	30 deleted	
24	32	222	82,64	DA = BA? = TA?	Leave as is		
25	45	214	77,14	Experienced DA knows the value of the feedback loop (findings in FMI)	Delete 45 & 47 => Add 301		
26	30	169	86,85	Makes no sense	Leave as is		
27	33	190	81,21	If BAD/SAD contain BA and implementation is compliant to BAD/SAD the domain is aligned with BA-> but Raymond claims no sense	Leave as is	33 is cause 190	
28	33	192	84,26	Coincidence?	Leave as is		
29	25	38	84,67	A lot of communication in FMI	Delete 25 & 38 => Add 302		
30	37	46	77,77	If BA is involved in start of the project, then feedback is implemented in architecture.	Leave as is		
31	45	47	77,2	DA = TA	Delete 45 & 47 => Add 301	We keep one architecture variable	
32	30	146	77,53	Makes sense	Leave as is		
33	30	149	79,46	Makes sense	Leave as is		
34	46	160	77,26	Makes no sense	Leave as is		
35	158	161	78,27	common PM tasks are req. Mgmnt and change mgmnt	Delete 161	161 = 162	
36	161	162	83,39	common PM tasks are req. Mgmnt and scope mgmnt	Delete 161	161 = 162	
37	161	175	83,14	Makes sense, but things are completely different	Delete 161	161 = 162	
38	149	203	77,79	Project changes influences delivered app services	Leave as is		
39	152	204	81,59	Makes no sense	Leave as is		
40	47	207	77,71	Makes no sense	Delete 45 & 47 => Add 301		
41	47	222	80,58	Architecture is applied, also for feedback	Delete 45 & 47 => Add 301		
42	146	223	78,4	Coincidence Bus. complexity results in higher tech. complexity	Leave as is		Interesting
43	169	203	83,74	Makes no sense	Leave as is		
44	177	210	82,96	Coincidence, however, bad tech.req require good development team	Delete 210 & 219 => Add 300		
45	176	222	78,72		Leave as is		
46	180	222	77,65	Coincidence	Leave as is		
47	174	230	81,37		Leave as is		
48	175	230	84,14	Makes sense	Leave as is		
49	162	172	78,3	Makes sense	Leave as is		
50	162	174	82,29	Makes sense	Leave as is		
51	162	175	78,43	Managing scope is related to clarity of acceptance requirements	Leave as is		Managing scope contains many factors
52	162	177	83,27	Managing scope is related to clarity of technical requirements	Leave as is		Managing scope contains many factors
53	162	179	83,68	Managing scope is related to quality of project proposal	Leave as is		Managing scope contains many factors
54	162	181	83,24	Managing scope is related to quality of project proposal	Delete 181	181 is part of 174	Managing scope contains many factors
55	172	174	83,24	Scope is related to functional requirements	Delete 172	172 is part of 174	
56	175	177	81,51	Makes sense	Leave as is		
57	174	181	77,39	project proposal is related to functional requirements	Delete 181	181 is part of 174	
58	177	181	77,15		Delete 181	181 is part of 174	
59	179	181	88,59	Consistent proposal correlated with extensive review	Delete 181	179 is part of 181	
60	180	198	79,24	Coincidence	Leave as is		
61	189	191	81,72	Both questions related to architecture	Delete 189 & 191 => Add 304	Delete and introduce "alignment of the domain with common arch"	
62	191	199	78,73		Delete 199		
63	186	207	79,54	Coincidence	Leave as is		
64	211	213	78,58	Coincidence	Leave as is		
65	209	215	80,73	Makes no sense	Leave as is		
66	212	215	79,1	Makes no sense	Leave as is		
67	210	219	79,38	Overall experience is introduced	Delete 210 & 219 => Add 300		
68	207	222	77,96		Leave as is		
69	214	222	77,01	Makes sense	Leave as is		
70	22	301			Delete 45 & 47 => Add 301		new
71	177	300			Delete 210 & 219 => Add 300		new
72	207	301			Delete 45 & 47 => Add 301		new
73	214	301			Delete 45 & 47 => Add 301		new
74	222	301			Delete 45 & 47 => Add 301		new

Appendix I. Input-output factors analysis

Vraag		Budget			Date			Total	Interpretation for budget					Interpretation for Date				
Num	Description	A	V	R	A	V	R		Finding	Significance	Interpretation	Size of effect	Comment	Finding	Significance	Interpretation	Size of effect	Comment
3	Business participation in budget setting		T		C		C	3	Trend: Higher participation of the business is correlated with higher reliability of budget	p=5,6%	Business participation allows better information and so better setting of budget		Not significant after removal outliers	More business participation correlates with higher time overrun	p=2,8%/3,7%		Rsq = 25,7%	
4	% of the domein arch. realized		C					1					No consequences					
9	Tech. Arch. Complete		C		T			2					Not significant after removal outliers		P=6,2%		Rsq=38.6%	Not enough data for conclusions
21	BAD/SAD discussed with business	C-T	C-NS					2	TREND: BAD/SAD discussed 5 is correlated with higher overrun than 3, 4 or 6.	P=7,1%	?		Two outliers removed from here					
23	Involvement of EA in FMI		T					1					Not significant after removal outliers					
31	What architecture method was used?		C					1					Not significant after removal outliers					
36	EA met often with PT in FMI				T			1						Insufficient trend for conclusions	P=6,7%			
37	BA met often with PT in FMI			C				1	More meetings are correlated with more budget overrun.	P=3%	Symptom of problem within project, ether complexity or other problem, which require the BA to have more participation							
39	# meetings of BA, DA and EA in FMI		T			T		2					Not significant after removal outliers	one a month correlates with lowest variance, less or more with higher time variance	P=8,9%			
42	# of BA's		T					1	Involvement of BA correlates with higher overrun.	P=5,5%	Involvement of BA only with more complex projects, which are harder to manage		Not significant after removal outliers					
46	Impl team feedback to BArchitecture				C	T		2										Not enough data for conclusions
146	Technical complexity		C					1					Not significant after removal outliers					
147	Sponsorship level of proj	T		C				2	Higher level of sponsorship correlates with higher budget overrun	P=3,6%		Rsq = 12,5%	Variance and Anova Not significant after removal outliers					
150	Project scope change		C					1	Decrease of project scope during execution is related to lower budget reliability	P=1,3%								
152	# steering committee meetings / quarter	C						1					Not significant after removal outliers					
156	Amount of days it took, on average, to solve issues		C					1					Not significant after removal outliers					
158	Change management in the process		C				T	2					Not significant after removal outliers		P=5,3%		Rsq=21,7%	Not enough data for conclusions
160	PM Progress measurement	T	C					2					Not significant after removal outliers					
162	PM manages scope of project				C		C	2										Not enough data for conclusions
170	Main reasosn project		C					1					Not significant after removal outliers					
174	Quality of functional specifications		T				T	2					Not significant after removal outliers	Higher quality functional specs seems to correlate with higher time overrun	P=7,3%			
177	Quality of technical requirements		T					1					Not significant after removal outliers					
179	Project proposal review				C		C	2						Higher quality of project proposal review correlates with higher time overrun.	P=3,3%/1.1%			
180	Quality of process initial budget setting	T		T				2					Not significant after removal outliers					
188	Increase/Decrease of awareness				T	C	C	3										Not relevant for time overrun
196	Increase of business value		T					1	Some indication that higher business value correlates with higher reliability	P=10,2%								
197	Type of Business value		C					1					Not significant after removal outliers					
200	Increase/Decrease Security risks					T		1										Not enough data for conclusions
206	Delivered functionality						T	1						Higher level of delivered functionality correlates with on time delivery	p=6%		Rsq = 18,8%	
207	Delivered generic services are reused		C					1					Not relevant for budget overrun					
208	Conformance of NFR's in FMI		C					1					Not significant after removal outliers					
211	BA general experience				T		T	2										Not enough data for conclusions
212	PM general experience				C		C	2										Not enough data for conclusions
213	EA general experience						T	1										Not enough data for conclusions
214	DA general experience	C		T				2					Not significant after removal outliers					
216	PM specific experience		C		C			2					Not significant after removal outliers					Not enough data for conclusions
217	EA specific experience				C			1										Not enough data for conclusions
218	DA specific experience		C	T	T			3					Not significant after removal outliers	level 5 correlates with high overrun, 4 and 6 with lower time overrun	P=7,1%			
220	Quality of BAD/SAD						C	1						Higher quality of BAD/SAD correlates with higher overrun				
224	# Major changes due to architecture		C					1					Not significant after removal outliers					
230	High business value of func requirements		C					1					Not significant after removal outliers					
231	At start of project, existing BArchitecture was clear		C					1	No consequences									
301	Impl team feedback changed architecture?						T	1						More implementation feedback correlates with more time-overrun	P=6,7%			
302	Meetings between DA & project team during FMI				C	C	C	3						Higher frequency of meetings correlate with more time overrun	P=1,7%			Not enough data for ANOVa/variance
303	Architect involvement during budget setting				T		C	2						More involvement in budget setting is correlated with more time overrun	P=6,4%/2,8%			
304	Alignment of domain because of project		T	T	T			3					Not significant after removal outliers		P=7,5%			Not enough data for conclusions
524	DA experience		T	C				2					Not significant after removal outliers					
525	EA experience				T			1						More experience of EA is correlated with lower project overrun	P=9,5			
527	Requirements specification quality		T				T	2					Not significant after removal outliers	Higher quality of specification is correlated with more time-overrun	P=5,7% (subset)			
528	Involvement of architects in FMI		T					1					Not significant after removal outliers					
529	PM Skills						T	1										Not enough data for conclusions
530	Quality of budget setting		T				C	2					Not significant after removal outliers	Higher time overrun is correlated with higher quality of budget setting	P=3,8%/P=9% (without outliers)		Rsq = 22,2%/14,4%	
Total		6	30	7	16	5	17	81										

Appendix J. Input-input factors K-W analysis

	Q	2	3	4	5	9	13	21	22	23	24	30	31	32	33	36	37	39	42	46	146	147	149	150	152	155	156	158	159	160
Q	C	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
2	1	0	0,096	0,1	0,798	0,524	0,738	0,804	0,118	0,073	0,036	0,615	0,163	0,214	0,019	0,56	0,478	0,109	0,721	0,037	0,338	0,853	0,424	0,696	0,497	0,034	0,484	0,332	0,443	0,242
3	2	0,945	0	0,493	0,126	0,324	0,461	0,28	0,236	0,269	0,033	0,02	0,983	0,488	0,441	0,065	0,219	0,217	0,013	0,067	0,839	0,131	0,142	0,462	0,462	0,621	0,208	0,224	0,285	0,687
4	3	0,162	0,085	0,002	0,391	0,492	0,541	0,656	0,114	0,584	0,164	0,039	0,465	0,169	0,036	0,449	0,701	0,769	0,342	0,077	0,1	0,299	0,346	0,787	0,287	0,368	0,317	0,507	0,19	0,776
5	4	0,448	0,993	0,218	0	0,113	0,084	0,465	0,862	0,826	0,262	0,578	0,006	0,626	0,37	0,186	0,581	0,425	0,285	0,329	0,205	0,323	0,248	0,974	0,126	0,962	0,445	0,312	0,231	0,875
9	5	0,349	0,928	0,323	0,116	0	0,077	0,713	0,095	0,942	0,117	0,382	0,223	0,52	0,586	0,436	0,679	0,887	0,308	0,863	0,483	0,627	0,417	0,63	0,722	0,313	0,231	0,302	0,24	0,245
13	6	0,164	0,367	0,174	0,008	0,358	0	0,025	0,933	0,322	0,457	0,069	0,004	0,233	0,093	0,538	0,71	0,312	0,686	0,884	0,913	0,174	0,433	0,599	0,769	0,405	0,331	0,213	0,186	0,575
21	7	0,531	0,011	0,519	0,161	0,756	0,023	0	0,196	0,013	0,61	0,072	0,034	0,326	0,095	0,051	0,163	0,446	0,86	0,07	0,464	0,541	0,283	0,522	0,999	0,037	0,741	0,046	0,325	0,774
22	8	0,062	0,016	0,051	0,368	0,673	0,464	0,321	0	0,23	0,409	0,035	0,601	0,143	0,32	0,171	0,862	0,04	0,742	0,504	0,071	0,457	0,653	0,169	0,158	0,465	0,505	0,325	0,329	0,267
23	9	0,242	0,936	0,496	0,379	0,412	0,402	0,774	0,528	0	0,401	0,393	0,688	0,567	0,801	0,023	0,812	0,454	0,101	0,238	0,629	0,348	0,089	0,961	0,679	0,133	0,335	0,093	0,249	0,555
24	10	0,038	0,519	0,386	0,359	0,348	0,271	0,842	0,095	0,133	0	0,474	0,493	0,832	0,191	0,274	0,058	0,516	0,017	0,332	0,316	0,027	0,768	0,584	0,192	0,355	0,495	0,078	0,38	0,133
30	11	0,473	0,011	0,525	0,579	0,149	0,009	0,015	0,58	0,034	0,671	0	0,582	0,322	0,884	0,104	0,285	0,348	0,569	0,714	0,112	0,483	0,12	0,621	0,998	0,131	0,2	0,159	0,318	0,254
31	12	0,48	0,52	0,637	0,01	0,21	0,077	0,012	0,858	0,48	0,437	0,809	0	0,895	0,233	0,628	0,865	0,289	0,274	0,55	0,57	0,907	0,708	0,825	0,332	0,643	0,518	0,175	0,128	0,203
32	13	0,222	0,021	0,06	0,431	0,345	0,114	0,391	0,41	0,079	0,614	0,238	0,402	0	0,031	0,124	0,495	0,391	0,953	0,597	0,441	0,225	0,873	0,562	0,08	0,355	0,314	0,904	0,112	0,687
33	14	0,562	0,394	0,106	0,307	0,186	0,398	0,382	0,173	0,746	0,358	0,096	0,1	0,133	0	0,118	0,935	0,527	0,646	0,405	0,235	0,134	0,398	0,65	0,59	0,727	0,208	0,565	0,518	0,663
36	15	0,407	0,713	0,533	0,157	0,907	0,505	0,855	0,605	0,039	0,692	0,152	0,348	0,429	0,186	0	0,033	0,08	0,235	0,138	0,612	0,24	0,422	0,33	0,736	0,398	0,694	0,445	0,556	0,833
37	16	0,187	0,404	0,438	0,259	0,592	0,246	0,763	0,608	0,712	0,151	0,233	0,29	0,495	0,359	0,008	0	0,082	0,086	0,158	0,685	0,778	0,168	0,625	0,262	0,975	0,665	0,138	0,076	0,128
39	17	0,113	0,633	0,264	0,532	0,626	0,858	0,089	0,878	0,614	0,628	0,474	0,232	0,097	0,06	0,368	0,257	0	0,61	0,214	0,278	0,435	0,239	0,523	0,371	0,112	0,413	0,401	0,311	0,189
42	18	0,912	0,568	0,245	0,293	0,182	0,919	0,799	0,314	0,065	0,029	0,631	0,04	0,906	0,884	0,454	0,576	0,54	0	0,208	0,332	0,059	0,02	0,365	0,156	0,864	0,476	0,299	0,202	0,705
46	19	0,439	0,86	0,595	0,644	0,259	0,596	0,963	0,892	0,641	0,992	0,261	0,155	0,639	0,916	0,123	0,308	0,018	0,227	0	0,906	0,473	0,756	0,275	0,77	0,666	0,712	0,299	0,071	0,037
146	20	0,087	0,08	0,533	0,588	0,196	0,684	0,239	0,054	0,283	0,15	0,122	0,712	0,29	0,368	0,078	0,406	0,207	0,194	0,711	0	0,719	0,054	0,102	0,451	0,353	0,328	0,239	0,096	0,763
147	21	0,825	0,277	0,423	0,394	0,404	0,176	0,531	0,058	0,25	0,188	0,46	0,07	0,293	0,576	0,245	0,434	0,169	0,117	0,244	0,846	0	0,411	0,278	0,594	0,95	0,163	0,584	0,232	0,309
149	22	0,31	0,347	0,743	0,439	0,389	0,77	0,466	0,177	0,101	0,497	0,108	0,498	0,131	0,914	0,467	0,161	0,877	0,123	0,338	0,044	0,537	0	0,231	0,347	0,117	0,278	0,147	0,257	0,517
150	23	0,89	0,266	0,19	0,178	0,54	0,781	0,348	0,37	0,977	0,209	0,573	0,456	0,788	0,598	0,169	0,1	0,449	0,118	0,195	0,129	0,059	0,263	0	0,217	0,362	0,52	0,101	0,195	0,962
152	24	0,143	0,668	0,245	0,511	0,574	0,406	0,924	0,387	0,596	0,421	0,978	0,123	0,82	0,631	0,897	0,179	0,513	0,288	0,48	0,251	0,297	0,562	0,089	0,001	0,426	0,834	0,045	0,186	0,45
155	25	0,804	0,058	0,595	0,798	0,351	0,207	0,696	0,315	0,522	0,227	0,317	0,926	0,285	0,369	0,292	0,927	0,243	0,55	0,219	0,689	0,435	0,123	0,541	0,884	0	0,464	0,552	0,213	0,163
156	26	0,754	0,973	0,668	0,659	0,638	0,901	0,448	0,382	0,659	0,204	0,712	0,631	0,069	0,452	0,933	0,675	0,038	0,082	0,724	0,167	0,346	0,519	0,608	0,254	0,359	0,012	0,546	0,384	0,73
158	27	0,247	0,245	0,647	0,487	0,057	0,099	0,052	0,754	0,001	0,125	0,132	0,016	0,799	0,804	0,342	0,063	0,358	0,164	0,236	0,614	0,409	0,532	0,502	0,127	0,562	0,954	0	0,038	0,009
159	28	0,765	0,501	0,287	0,263	0,956	0,219	0,614	0,527	0,133	0,741	0,072	0,163	0,669	0,139	0,569	0,711	0,049	0,831	0,129	0,864	0,224	0,975	0,383	0,131	0,347	0,703	0,082	0	0,11
160	29	0,056	0,993	0,257	0,478	0,74	0,756	0,573	0,364	0,255	0,953	0,175	0,409	0,174	0,9	0,334	0,133	0,059	0,972	0,009	0,924	0,26	0,959	0,668	0,083	0,145	0,886	0,017	0,024	0
162	30	0,045	1	0,359	0,516	0,068	0,296	0,83	0,492	0,606	0,422	0,755	0,272	0,316	0,693	0,19	0,186	0,473	0,003	0,719	0,611	0,373	0,2	0,045	0,132	0,137	0,639	0,019	0,186	0,201
163	31	0,639	0,042	0,144	0,008	0,94	0,316	0,235	0,831	0,899	0,156	0,456	0,01	0,614	0,543	0,362	0,181	0,159	0,293	0,405	0,604	0,296	0,791	0,708	0,093	0,493	0,123	0,756	0,584	0,578
167	32	0,254	0,837	0,266	0,663	0,375	0,678	0,876	0,663	0,225	0,93	0,268	0,65	0,387	0,707	0,919	0,29	0,255	0,086	0,12	0,816	0,763	0,748	0,771	0,254	0,325	0,075	0,642	0,387	0,589
169	33	0,49	0,516	0,159	0,207	0,907	0,268	0,092	0,477	0,227	0,411	0,023	0,592	0,432	0,229	0,346	0,742	0,556	0,164	0,768	0,12	0,494	0,022	0,412	0,778	0,26	0,198	0,302	0,215	0,974
170	34	0,777	0,289	0,659	0,709	0,562	0,236	0,101	0,701	0,145	0,51	0,577	0,096	0,686	0,48	0,699	0,955	0,37	0,622	0,107	0,675	0,153	0,867	0,61	0,797	0,573	0,771	0,042	0,318	0,888
174	35	0,415	0,606	0,901	0,486	0,531	0,669	0,577	0,308	0,28	0,379	0,489	0,012	0,626	0,55	0,221	0,755	0,758	0,07	0,223	0,256	0,29	0,061	0,065	0,27	0,575	0,446	0,167	0,075	0,825
175	36	0,072	0,585	0,445	0,152	0,188	0,258	0,122	0,62	0,609	0,098	0,149	0,237	0,863	0,471	0,298	0,529	0,651	0,121	0,795	0,715	0,229	0,375	0,005	0,226	0,112	0,583	0,073	0,024	0,218
176	37	0,278	0,053	0,135	0,408	0,48	0,46	0,648	0,156	0,776	0,575	0,056	0,629	0,03	0,513	0,708	0,113	0,336	0,26	0,253	0,745	0,337	0,443	0,29	0,178	0,171	0,785	0,215	0,387	0,208
177	38	0,08	0,436	0,637	0,078	0,109	0,226	0,328	0,43	0,465	0,265	0,404	0,662	0,537	0,751	0,311	0,81	0,512	0,393	0,335	0,946	0,359	0,649	0,082	0,09	0,372	0,558	0,143	0,072	0,422
179	39	0,422	0,023	0,371	0,373	0,383	0,224	0,571	0,042	0,84	0,928	0,173	0,469	0,178	0,433	0,086	0,752	0,091	0,215	0,515	0,385	0,085	0,982	0,597	0,372	0,898	0,548	0,499	0,059	0,824
180	40	0,404	0,572	0,946	0,888	0,232	0,889	0,413	0,506	0,702	0,559	0,684	0,215	0,743	0,227	0,133	0,136	0,774	0,506	0,143	0,478	0,274	0,2	0,744	0,228	0,213	0,644	0,739	0,145	0,544
186	41	0,176	0,966	0,127	0,485	0,45	0,398	0,91	0,836	0,193	0,878	0,528	0,737	0,689	0,676	0,067	0,369	0,091	0,502	0,405	0,565	0,996	0,921	0,205	0,787	0,288	0,601	0,622	0,85	0,901
188	42	0,576	0,306	0,564	0,548	0,453	0,529	0,803	0,608	0,899	0,611	0,281	0,424	0,56	0,664	0,447	0,526	0,063	0,768	0,28	0,449	0,569	0,304	0,228	0,733	0,144	0,695	0,592	0,517	0,238
190	43	0,258	0,955	0,732	0,105	0,263	0,105	0,349	0,48	0,455	0,182	0,229	0,046	0,767	0,038	0,037	0,287	0,407	0,306	0,071	0,312	0,882	0,093	0,977	0,483	0,999	0,524	0,469	0,069	0,952
192	44	0,149	0,161	0,261	0,257	0,062	0,532	0,213	0,373	0,098	0,663	0,012	0,277	0,098	0,038	0,284	0,905	0,734	0,326	0,027	0,235	0,735	0,516	0,681	0,675	0,209	0,429	0,281	0,144	0,422
196	45	0,521	0,327	0,533	0,757	0,423	0,248	0,834	0,471	0,121	0,683	0,28	0,172	0,106	0,13	0,575	0,755	0,614	0,748	0,316	0,584	0,271	0,563	0,708	0,248	0,563	0,408	0,76	0,736	0,53
197	46	0,18	0,291	0,707	0,729	0,31	0,642	0,807	0,668	0,232	0,81	0,658	0,475	0,286	0,282	0,662	0,266	0,208	0,227	0,378	0,896	0,312	0,276	0,978	0,346	0,231	0,566	0,405	0,487	0,734
198	47	0,196	0,167	0,868	0,791	0,467	0,989	0,913	0,537	0,875	0,7	0,679	0,843	0,839	0,225	0,485	0,37	0,023	0,706	0,499	0,358	0,362	0,064	0,542	0,841	0,17	0,308	0,909	0,932	0,333
200	48	0,24	0,445	0,391	0,176	0,817	0,427	0,279	0,049	0,012	0,652	0,169	0,355	0,548	0,302	0,288	0,538	0,607	0,035	0,172	0,269	0,149	0,136	0,821	0,193	0,529	0,362	0,144	0,533	0,245
201	49	0,245	0,341	0,89	0,386	0,649	0,952	0,833	0,49	0,617	0,473	0,566	0,869	0,47	0,166	0,337	0,343	0,293	0,198	0,859	0,159	0,205	0,33	0,454	0,618	0,946	0,577	0,143	0,381	0,882
202	50	0,587	0,564	0,426	0,462	0,876	0,767	0,329	0,084	0,46	0,925	0,225	0,378	0,467	0,205	0,769	0,444	0,012	0,366	0,13	0,011	0,18	0,32	0,321	0,209	0,197	0,149	0,406	0,337	0,515
203	51	0,837	0,406	0,338	0,1	0,677	0,539	0,974	0,371	0,345	0,005	0,076	0,468	0,325	0,137	0,607	0,284	0,282	0,016	0,815	0,031	0,011	0,192	0,162	0,499	0,882	0,493	0,202	0,091	0,069
204	52	0,495	0,279	0,272	0,207	0,83	0,201	0,361	0,671	0,798	0,405	0,092	0,019	0,428	0,063	0,681	0,176	0,018	0,055	0,706	0,146	0,625	0,087	0,833	0,162	0,822	0,387	0,736	0,014	0,586
205	53	0,471	0,267	0,234	0,054	0,044	0,043	0,305	0,301	0,656	0,66	0,137	0,043	0,322	0,083	0,954	0,571	0,556	0,278	0,63	0,136	0,803	0,334	0,892	0,56	0,429	0,64	0,531	0,178	0,322
206	54	0,237	0,247	0,112	0,472	0,911	0,528	0,637	0,38	0,177	0,169	0,026	0,999	0,923	0,496	0,134	0,339	0,291	0,117	0,072	0,248	0,703	0,201	0,284	0,545	0,552	0,178	0,372	0,478	0,897
207	55	0,516	0,201	0,625	0,151	0,758	0,462	0,461	0,487	0,8	0,434	0,056	0,998	0,252	0,775	0,472	0,389	0,473	0,421	0,21	0,654	0,78	0,536	0,472	0,45	0,244	0,312	0,363	0,11	0,555
208	56	0,23	0,086	0,08	0,111	0,58	0,478	0,671	0,791	0,423	0,241	0,262	0,497	0,449	0,428	0,312	0,146	0,962	0,068	0,168	0,523	0,096	0,302	0,299	0,104	0,211	0,18	0,161	0,792	0,411
209	57	0,153	0,24	0,098	0,725	0,866	0,016	0,916	0,952	0,568	0,212	0,023	0,93	0,089	0,725	0,207	0,07	0,391	0,457	0,659	0,86	0,484	0,309	0,85	0,576	0,406	0,347	0,639	0,352	0,632
211	58	0,295	0,278	0,465	0,183	0,179	0,573	0,974	0,699	0,455	0,087	0,373	0,695	0,718	0,666	0,34	0,272	0,663	0,131	0,761	0,881	0,14	0,038	0,87	0,288	0,159	0,442	0,172	0,466	0,265
212	59	0,182	0,288	0,324	0,571	0,275	0,151	0,277	0,543	0,522	0,106	0,028	0,361	0,579	0,104	0,331	0,256	0,707	0,23	0,858	0,808	0,669	0,059	0,992	0,15	0,241	0,349	0,025	0,603	0,708
213	60	0,17	0,284	0,301	0,211	0,217	0,824	0,502	0,528	0,605	0,242	0,011	0,805	0,878	0,197	0,107	0,558	0,334	0,471	0,353	0,075	0,886	0,053	0,993	0,91	0,631	0,537	0,381	0,048	0,423
214	61	0,354	0,027	0,035	0,086	0,149	0,075	0,677	0,458	0,094	0,614	0,117	0,042	0,306	0,14	0,231	0,408	0,038	0,491	0,147	0,408	0,382	0,908	0,493	0,306	0,588	0,826	0,167	0,108	0,151
215	62	0,113	0,934	0,174	0,204	0,424	0,56	0,549	0,811	0,192	0,279	0,478	0,451	0,221	0,285	0,064	0,169	0,78	0,885	0,365	0,289	0,549	0,272	0,704	0,405	0,473	0,56	0,236	0,106	0,387
216	63	0,1	0,239	0,311	0,347	0,146	0,52	0,06	0,139	0,187	0,984	0,64	0,776	0,307	0,108	0,115	0,104	0,185	0,73	0,246	0,217	0,593	0,929	0,324	0,085	0,173	0,57	0,383	0,799	0,702
217	64	0,406	0,438	0,216	0,497	0,956	0,188	1	0,962	0,325	0,103	0,304	0,368	0,891	0,353	0,12	0,721	0,399	0,172	0,571	0,64	0,111	0,777	0,522	0,899	0,639	0,475	0,852	0,468	0,396
218	65	0,309	0,43	0,72	0,284	0,833	0,062	0,509	0,337	0,073	0,131	0,556	0,351	0,623	0,581	0,549	0,86	0,327	0,158	0,47	0,099	0,551	0,673	0,45	0,256	0,829	0,418	0,348	0,21	0,516
220	66	0,063	0,041	0,373	0,624	0,294	0,012	0,033	0,085	0,207	0,091	0,026	0,727	0,046	0,392	0,036	0,08	0,028	0,837	0,226	0,4	0,94	0,826	0,781	0,997	0,068	0,238	0,14	0,032	0,757
222	67	0,188	0,05	0,262	0,136	0,023	0,229	0,575	0,137	0,725	0,276	0,179	0,805	0,057	0,133	0,132	0,504	0,457	0,714	0,404	0,545	0,592	0,956	0,95	0,336	0,654	0,547	0,522	0,105	0,325
223	68	0,395	0,154	0,214	0,566	0,117	0,355	0,655	0,127	0,419	0,081	0,084	0,242	0,174	0,474	0,229	0,521	0,608	0,037	0,49	0,023	0,37	0,144	0,277	0,521	0,357	0,375	0,15	0,063	0,329
224	69	0,009	0,213	0,093	0,165	0,763	0,923	0,537	0,187	0,134	0,12	0,187	0,157	0,327	0,059	0,744	0,903	0,139	0,652	0,168	0,171	0,436	0,066	0,915	0,093	0,124	0,423	0,334	0,568	0,429
225	70	0,052	0,262	0,293	0,265	0,644	0,831	0,453	0,561	0,82	0,244	0,191	0,297	0,624	0,212	0,176	0,552	0,541	0,051	0,583	0,219	0,158	0,013	0,629	0,451	0,194	0,257	0,814	0,274	0,324
230	71	0,201	0,301	0,658	0,18	0,611	0,054	0,125	0,158	0,3	0,097	0,182	0,275	0,59	0,49	0,313	0,237	0,23	0,217	0,164	0,35	0,649	0,464	0,042	0,398	0,062	0,145	0,184	0,391	0,593
231	72	0,456	0,307	0,701	0,132	0,029	0,331	0,44	0,947	0,517	0,49	0,707	0,553	0,677	0,279	0,208	0,851	0,596	0,678	0,438	0,875	0,789	0,369	0,696	0,579	0,199	0,428	0,273	0,066	0,407
300	73	0.183	0,274	0,316	0,564	0,174	0,621	0,011	0,31	0,008	0,17	0,08	0,909	0,838	0,577	0,606	0,573	0,728	0,524	0,374	0,565	0,532	0,73	0,274	0,153	0,524	0,168	0,03	0,041	0,143
301	74	0,236	0,307	0,446	0,081	0,283	0,448	0,663	0,242	0,938	0,705	0,152	0,427	0,228	0,03	0,356	0,594	0,317	0,657	0,203	0,169	0,665	0,561	0,406	0,762	0,915	0,441	0,423	0,161	0,616
302	75	0.385	0,054	0,559	0,42	0,06	0,291	0,092	0,033	0,095	0,494	0,027	0,17	0,667	0,421	0,097	0,766	0,138	0,112	0,934	0,057	0,013	0,077	0,412	0,478	0,837	0,43	0,429	0,263	0,963
303	76	0,21	0,013	0,067	0,195	0,126	0,59	0,659	0,17	0,079	0,315	0,596	0,316	0,227	0,136	0,526	0,248	0,828	0,463	0,189	0,823	0,426	0,344	0,751	0,09	0,107	0,293	0,29	0,473	0,582
304	77	0,26	0,102	0,148	0,787	0,382	0,212	0,088	0,337	0,06	0,668	0,107	0,072	0,199	0,062	0,342	0,343	0,234	0,418	0,302	0,491	0,218	0,188	0,139	0,043	0,309	0,754	0,13	0,122	0,56
501	78	0,245	0,248	0,385	0,064	0,437	0,061	0,071	0,7	0,382	0,634	0,097	0,036	0,932	0,026	0,443	0,982	0,193	0,768	0,337	0,162	0,69	0,385	0,746	0,509	0,69	0,414	0,587	0,618	0,885
502	79	0,245	0,248	0,385	0,064	0,437	0,061	0,071	0,7	0,382	0,634	0,097	0,036	0,932	0,026	0,443	0,982	0,193	0,768	0,337	0,162	0,69	0,385	0,746	0,509	0,69	0,414	0,587	0,618	0,885
503	80	0,245	0,248	0,385	0,064	0,437	0,061	0,071	0,7	0,382	0,634	0,097	0,036	0,932	0,026	0,443	0,982	0,193	0,768	0,337	0,162	0,69	0,385	0,746	0,509	0,69	0,414	0,587	0,618	0,885
504	81	0,146	0,234	0,615	0,205	0,396	0,144	0,15	0,871	0,825	0,911	0,407	0,075	0,451	0,123	0,059	0,645	0,036	0,923	0,625	0,465	0,443	0,699	0,328	0,792	0,496	0,469	0,296	0,407	0,967
505	82	0,146	0,234	0,615	0,205	0,396	0,144	0,15	0,871	0,825	0,911	0,407	0,075	0,451	0,123	0,059	0,645	0,036	0,923	0,625	0,465	0,443	0,699	0,328	0,792	0,496	0,469	0,296	0,407	0,967
506	83	0,245	0,248	0,385	0,064	0,437	0,061	0,071	0,7	0,382	0,634	0,097	0,036	0,932	0,026	0,443	0,982	0,193	0,768	0,337	0,162	0,69	0,385	0,746	0,509	0,69	0,414	0,587	0,618	0,885
507	84	0,245	0,248	0,385	0,064	0,437	0,061	0,071	0,7	0,382	0,634	0,097	0,036	0,932	0,026	0,443	0,982	0,193	0,768	0,337	0,162	0,69	0,385	0,746	0,509	0,69	0,414	0,587	0,618	0,885
508	85	0,245	0,248	0,385	0,064	0,437	0,061	0,071	0,7	0,382	0,634	0,097	0,036	0,932	0,026	0,443	0,982	0,193	0,768	0,337	0,162	0,69	0,385	0,746	0,509	0,69	0,414	0,587	0,618	0,885
509	86	0,09	0,241	0,5	0,459	0,4	0,18	0,205	0,707	0,912	0,875	0,443	0,098	0,303	0,16	0,067	0,539	0,054	0,747	0,83	0,715	0,278	0,817	0,215	0,983	0,373	0,449	0,123	0,2	0,892
510	87	0,535	0,223	0,648	0,357	0,2	0,676	0,174	0,16	0,369	0,155	0,18	0,102	0,25	0,375	0,317	0,78	0,876	0,125	0,478	0,145	0,097	0,161	0,481	0,433	0,483	0,362	0,052	0,228	0,699
511	88	0,157	0,463	0,199	0,214	0,219	0,398	0,015	0,271	0,277	0,737	0,679	0,851	0,864	0,162	0,485	0,241	0,213	0,246	0,441	0,45	0,346	0,791	0,18	0,026	0,33	0,275	0,307	0,894	0,583
512	89	0,088	0,135	0,418	0,495	0,451	0,311	0,454	0,677	0,755	0,875	0,254	0,07	0,665	0,064	0,202	0,312	0,028	0,874	0,46	0,67	0,731	0,708	0,212	0,942	0,239	0,534	0,24	0,051	0,617
513	90	0,127	0,425	0,331	0,626	0,292	0,861	0,367	0,554	0,01	0,542	0,371	0,51	0,509	0,31	0,065	0,675	0,001	0,409	0,189	0,085	0,572	0,039	0,285	0,352	0,168	0,419	0,248	0,222	0,88
514	91	0,668	0,273	0,458	0,056	0,83	0,837	0,389	0,642	0,23	0,061	0,147	0,173	0,511	0,044	0,182	0,429	0,057	0,054	0,503	0,191	0,548	0,591	0,383	0,444	0,29	0,491	0,415	0,677	0,916
516	93	0,09	0,241	0,5	0,459	0,4	0,18	0,205	0,707	0,912	0,875	0,443	0,098	0,303	0,16	0,067	0,539	0,054	0,747	0,83	0,715	0,278	0,817	0,215	0,983	0,373	0,449	0,123	0,2	0,892
517	94	0,15	0,474	0,296	0,71	0,435	0,963	0,196	0,741	0,102	0,813	0,187	0,537	0,636	0,103	0,268	0,93	0,022	0,957	0,197	0,252	0,536	0,34	0,772	0,659	0,307	0,6	0,478	0,364	0,705
518	95	0,079	0,532	0,416	0,001	0,609	0,001	0,017	0,865	0,518	0,362	0,749	0,002	0,875	0,041	0,316	0,585	0,252	0,178	0,519	0,199	0,914	0,16	0,797	0,804	0,969	0,494	0,78	0,274	0,999
519	96	0,245	0,248	0,385	0,064	0,437	0,061	0,071	0,7	0,382	0,634	0,097	0,036	0,932	0,026	0,443	0,982	0,193	0,768	0,337	0,162	0,69	0,385	0,746	0,509	0,69	0,414	0,587	0,618	0,885
520	97	0,098	0,254	0,881	0,116	0,232	0,085	0,052	0,554	0,621	0,476	0,227	0,125	0,466	0,093	0,161	0,902	0,494	0,314	0,18	0,112	0,428	0,603	0,426	0,541	0,916	0,438	0,173	0,334	0,949
521	98	0,294	0,206	0,5	0,113	0,253	0,678	0,244	0,266	0,007	0,03	0,462	0,289	0,911	0,913	0,465	0,999	0,541	0,001	0,134	0,445	0,016	0,315	0,78	0,337	0,722	0,377	0,126	0,871	0,656
522	99	0,125	0,275	0,164	0,412	0,149	0,635	0,217	0,264	0,013	0,069	0,761	0,202	0,754	0,507	0,187	0,558	0,524	0	0,249	0,586	0,077	0,24	0,721	0,567	0,797	0,286	0,197	0,785	0,82
523	100	0,163	0,239	0,432	0,436	0,15	0,609	0,031	0,313	0,196	0,849	0,337	0,944	0,467	0,075	0,421	0,099	0,225	0,446	0,294	0,395	0,529	0,633	0,459	0,095	0,077	0,452	0,333	0,784	0,862
524	101	0,301	0,316	0,345	0,184	0,46	0,037	0,716	0,29	0,135	0,19	0,435	0,18	0,71	0,335	0,547	0,713	0,395	0,25	0,539	0,147	0,683	0,825	0,619	0,323	0,773	0,665	0,176	0,111	0,298
525	102	0,437	0,49	0,211	0,886	0,952	0,519	0,95	0,917	0,214	0,705	0,168	0,719	0,643	0,054	0,054	0,547	0,473	0,505	0,244	0,894	0,968	0,675	0,453	0,668	0,612	0,904	0,406	0,22	0,374
527	104	0,415	0,606	0,901	0,486	0,531	0,669	0,577	0,308	0,28	0,379	0,489	0,012	0,626	0,55	0,221	0,755	0,758	0,07	0,223	0,256	0,29	0,061	0,065	0,27	0,575	0,446	0,167	0,075	0,825
528	105	0,133	0,58	0,141	0,4	0,439	0,987	0,377	0,861	0,001	0,321	0,331	0,829	0,401	0,195	0,102	0,822	0,002	0,493	0,352	0,339	0,391	0,092	0,414	0,887	0,126	0,535	0,252	0,445	0,912
529	106	0,027	0,914	0,422	0,904	0,202	0,553	0,744	0,802	0,517	0,622	0,87	0,555	0,104	0,724	0,528	0,131	0,132	0,344	0,067	0,806	0,377	0,754	0,525	0,127	0,667	0,928	0,001	0,057	0
530	107	0,236	0	0,203	0,182	0,347	0,18	0,416	0,332	0,306	0,116	0,187	0,458	0,065	0,513	0,201	0,55	0,354	0,273	0,026	0,832	0,279	0,19	0,766	0,346	0,497	0,384	0,101	0,569	0,664
531	108	0,102	0,129	0,859	0,102	0,264	0,099	0,022	0,626	0,617	0,388	0,128	0,107	0,477	0,109	0,22	0,941	0,403	0,401	0,108	0,352	0,403	0,442	0,621	0,592	0,781	0,412	0,138	0,3	0,949
600	109																													
601	110																													

	Q	162	163	167	169	170	174	175	176	177	179	180	186	188	190	192	196	197	198	200	201	202	203	204	205	206	207	208	209	211
Q	C	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58
2	1	0,063	0,507	0,019	0,592	0,798	0,37	0,068	0,26	0,051	0,024	0,963	0,82	0,695	0,209	0,391	0,115	0,859	0,204	0,611	0,312	0,22	0,913	0,791	0,021	0,547	0,37	0,243	0,098	0,172
3	2	0,321	0,03	0,412	0,393	0,458	0,462	0,025	0,146	0,151	0,21	0,118	0,559	0,151	0,439	0,413	0,069	0,148	0,124	0,611	0,361	0,07	0,143	0,17	0,399	0,052	0,541	0,04	0,219	0,407
4	3	0,466	0,268	0,303	0,443	0,37	0,383	0,358	0,017	0,14	0,138	0,46	0,193	0,146	0,045	0,216	0,267	0,805	0,602	0,037	0,439	0,033	0,661	0,3	0,292	0,087	0,509	0,017	0,084	0,49
5	4	0,226	0,046	0,327	0,543	0,548	0,531	0,409	0,485	0,147	0,556	0,996	0,658	0,342	0,202	0,455	0,354	0,576	0,82	0,351	0,507	0,822	0,882	0,266	0,882	0,508	0,144	0,134	0,51	0,522
9	5	0,267	0,685	0,301	0,273	0,893	0,23	0,488	0,132	0,362	0,317	0,724	0,251	0,251	0,032	0,09	0,516	0,435	0,877	0,355	0,546	0,51	0,638	0,576	0,73	0,468	0,841	0,051	0,136	0,232
13	6	0,481	0,266	0,906	0,415	0,312	0,122	0,162	0,385	0,129	0,342	0,924	0,571	0,843	0,42	0,544	0,182	0,097	0,265	0,327	0,752	0,007	0,457	0,319	0,644	0,701	0,596	0,199	0,095	0,789
21	7	0,88	0,445	0,523	0,347	0,3	0,44	0,436	0,147	0,106	0,23	0,344	0,664	0,72	0,282	0,156	0,685	0,34	0,854	0,114	0,583	0,529	0,488	0,783	0,313	0,189	0,457	0,087	0,695	0,704
22	8	0,391	0,517	0,17	0,802	0,926	0,61	0,034	0,067	0,025	0,003	0,628	0,466	0,434	0,027	0,276	0,537	0,836	0,491	0,501	0,194	0,185	0,229	0,359	0,112	0,553	0,446	0,073	0,024	0,316
23	9	0,195	0,337	0,204	0,104	0,333	0,568	0,177	0,499	0,332	0,556	0,62	0,057	0,727	0,24	0,315	0,137	0,945	0,398	0,348	0,142	0,548	0,55	0,814	0,155	0,083	0,92	0,294	0,434	0,346
24	10	0,054	0,4	0,264	0,832	0,275	0,24	0,14	0,793	0,307	0,454	0,594	0,713	0,372	0,4	0,651	0,115	0,889	0,276	0,497	0,022	0,963	0,022	0,419	0,272	0,523	0,843	0,435	0,201	0,199
30	11	0,629	0,038	0,382	0,024	0,318	0,987	0,622	0,535	0,161	0,046	0,493	0,291	0,832	0,763	0,083	0,495	0,204	0,954	0,481	0,334	0,532	0,212	0,169	0,216	0,567	0,058	0,295	0,095	0,04
31	12	0,898	0,104	0,605	0,723	0,102	0,152	0,468	0,795	0,409	0,788	0,863	0,506	0,358	0,241	0,395	0,784	0,775	0,87	0,603	0,932	0,257	0,301	0,837	0,361	0,767	0,925	0,234	0,158	0,385
32	13	0,291	0,958	0,139	0,595	0,972	0,923	0,104	0,343	0,165	0,01	0,359	0,331	0,86	0,166	0,111	0,098	0,359	0,137	0,626	0,546	0,565	0,13	0,303	0,366	0,157	0,487	0,004	0,058	0,29
33	14	0,514	0,387	0,608	0,235	0,297	0,454	0,87	0,138	0,181	0,473	0,264	0,593	0,547	0,053	0,082	0,077	0,417	0,536	0,113	0,646	0,077	0,843	0,265	0,243	0,122	0,086	0,218	0,803	0,58
36	15	0,179	0,427	0,195	0,352	0,523	0,195	0,261	0,201	0,243	0,313	0,223	0,023	0,476	0,095	0,757	0,156	0,973	0,548	0,692	0,963	0,674	0,243	0,253	0,328	0,078	0,342	0,231	0,138	0,167
37	16	0,2	0,27	0,195	0,753	0,452	0,296	0,258	0,115	0,511	0,968	0,176	0,912	0,205	0,173	0,666	0,268	0,997	0,47	0,786	0,416	0,823	0,166	0,203	0,341	0,226	0,55	0,237	0,216	0,489
39	17	0,678	0,845	0,494	0,663	0,305	0,879	0,111	0,52	0,989	0,854	0,821	0,141	0,616	0,342	0,491	0,435	0,22	0,247	0,569	0,66	0,063	0,251	0,654	0,372	0,677	0,083	0,453	0,109	0,503
42	18	0,053	0,031	0,091	0,198	0,131	0,402	0,351	0,244	0,544	0,183	0,9	0,793	0,766	0,488	0,418	0,307	0,841	0,789	0,088	0,212	0,639	0,098	0,276	0,506	0,405	0,733	0,26	0,866	0,078
46	19	0,716	0,583	0,408	0,499	0,899	0,317	0,726	0,616	0,923	0,611	0,127	0,393	0,984	0,036	0,194	0,312	0,303	0,817	0,333	0,811	0,831	0,437	0,527	0,545	0,575	0,608	0,373	0,311	0,405
146	20	0,403	0,466	0,083	0,401	0,395	0,73	0,132	0,378	0,083	0,515	0,749	0,541	0,515	0,087	0,396	0,373	0,711	0,505	0,697	0,051	0,177	0,101	0,404	0,213	0,385	0,403	0,167	0,123	0,222
147	21	0,235	0,32	0,448	0,57	0,891	0,365	0,457	0,353	0,785	0,32	0,675	0,767	0,238	0,205	0,576	0,146	0,441	0,184	0,204	0,567	0,424	0,329	0,534	0,696	0,069	0,593	0,059	0,357	0,631
149	22	0,031	0,294	0,256	0,045	0,599	0,093	0,661	0,107	0,446	0,569	0,346	0,955	0,344	0,162	0,559	0,278	0,534	0,486	0,432	0,573	0,59	0,163	0,093	0,147	0,137	0,328	0,019	0,277	0,292
150	23	0,04	0,324	0,348	0,166	0,79	0,03	0,15	0,11	0,072	0,022	0,18	0,965	0,46	0,804	0,626	0,335	0,041	0,19	0,764	0,074	0,672	0,043	0,538	0,863	0,321	0,252	0,121	0,257	0,502
152	24	0,198	0,336	0,106	0,578	0,161	0,299	0,139	0,657	0,215	0,155	0,07	0,438	0,826	0,157	0,294	0,472	0,284	0,907	0,037	0,035	0,438	0,378	0,362	0,622	0,926	0,678	0,302	0,802	0,502
155	25	0,605	0,455	0,172	0,402	0,177	0,609	0,702	0,202	0,362	0,774	0,158	0,626	0,084	0,925	0,537	0,315	0,349	0,323	0,244	0,925	0,634	0,536	0,108	0,265	0,116	0,138	0,61	0,145	0,483
156	26	0,12	0,506	0,102	0,218	0,153	0,684	0,446	0,397	0,506	0,087	0,12	0,128	0,522	0,279	0,875	0,46	0,248	0,655	0,65	0,615	0,322	0,392	0,288	0,838	0,121	0,4	0,493	0,404	0,762
158	27	0,104	0,392	0,936	0,597	0,086	0,36	0,066	0,428	0,666	0,336	0,77	0,652	0,94	0,879	0,344	0,223	0,355	0,759	0,516	0,17	0,389	0,288	0,674	0,681	0,131	0,731	0,115	0,189	0,85
159	28	0,803	0,792	0,073	0,744	0,717	0,58	0,513	0,624	0,13	0,239	0,129	0,411	0,374	0,149	0,451	0,304	0,292	0,83	0,652	0,646	0,582	0,537	0,503	0,412	0,896	0,506	0,142	0,18	0,581
160	29	0,66	0,97	0,921	0,514	0,635	0,247	0,377	0,109	0,962	0,591	0,286	0,636	0,352	0,6	0,379	0,481	0,156	0,949	0,416	0,72	0,391	0,332	0,985	0,618	0,726	0,441	0,324	0,822	0,962
162	30	0	0,094	0,739	0,407	0,873	0,011	0,011	0,249	0,004	0	0,093	0,375	0,824	0,945	0,43	0,551	0,446	0,68	0,748	0,556	0,904	0,121	0,147	0,832	0,119	0,466	0,808	0,765	0,814
163	31	0,657	0	0,435	0,335	0,717	0,205	0,437	0,06	0,06	0,794	0,903	0,782	0,532	0,636	0,534	0,452	0,627	0,268	0,377	0,964	0,626	0,762	0,349	0,749	0,391	0,596	0,359	0,707	0,177
167	32	0,165	0,651	0	0,382	0,153	0,47	0,556	0,692	0,694	0,041	0,701	0,857	0,106	0,508	0,113	0,247	0,728	0,968	0,051	0,632	0,516	0,046	0,073	0,25	0,685	0,114	0,241	0,363	0,155
169	33	0,244	0,132	0,161	0	0,541	0,457	0,264	0,071	0,645	0,785	0,122	0,635	0,548	0,326	0,373	0,144	0,663	0,649	0,785	0,669	0,385	0,093	0,087	0,231	0,114	0,042	0,541	0,179	0,142
170	34	0,728	0,975	0,755	0,357	0	0,783	0,262	0,996	0,628	0,753	0,506	0,403	0,172	0,521	0,367	0,282	0,382	0,788	0,921	0,638	0,774	0,751	0,154	0,057	0,457	0,237	0,83	0,106	0,785
174	35	0,01	0,036	0,526	0,249	0,424	0	0,167	0,127	0,019	0,042	0,212	0,805	0,712	0,349	0,189	0,203	0,168	0,409	0,436	0,052	0,896	0,228	0,313	0,658	0,09	0,574	0,783	0,758	0,707
175	36	0,005	0,584	0,12	0,263	0,328	0,138	0	0,064	0,002	0,356	0,549	0,163	0,875	0,728	0,182	0,397	0,282	0,505	0,783	0,057	0,67	0,119	0,249	0,221	0,002	0,547	0,129	0,331	0,568
176	37	0,286	0,084	0,171	0,361	0,967	0,367	0,039	0	0,019	0,394	0,341	0,412	0,188	0,296	0,271	0,283	0,118	0,817	0,82	0,223	0,136	0,654	0,538	0,541	0,014	0,257	0,036	0,225	0,149
177	38	0,003	0,33	0,093	0,755	0,665	0,08	0,003	0,531	0	0,033	0,218	0,52	0,903	0,372	0,171	0,8	0,54	0,343	0,58	0,015	0,663	0,129	0,249	0,577	0,089	0,403	0,096	0,082	0,292
179	39	0,003	0,247	0,747	0,848	0,66	0,338	0,198	0,923	0,011	0	0,125	0,353	0,912	0,108	0,101	0,608	0,105	0,779	0,905	0,175	0,524	0,944	0,16	0,634	0,916	0,445	0,242	0,129	0,041
180	40	0,648	0,134	0,217	0,424	0,388	0,558	0,908	0,87	0,667	0,243	0	0,368	0,598	0,341	0,641	0,365	0,056	0,037	0,103	0,159	0,133	0,602	0,138	0,187	0,667	0,838	0,238	0,426	0,426
186	41	0,703	0,515	0,459	0,458	0,011	0,712	0,109	0,489	0,589	0,919	0,313	0	0,274	0,823	0,396	0,229	0,086	0,66	0,432	0,398	0,366	0,213	0,482	0,416	0,023	0,039	0,653	0,216	0,685
188	42	0,63	0,247	0,255	0,514	0,351	0,643	0,407	0,211	0,265	0,869	0,149	0,599	0	0,708	0,292	0,77	0,466	0,363	0,611	0,986	0,091	0,734	0,054	0,531	0,18	0,204	0,268	0,423	0,621
190	43	0,513	0,515	0,066	0,531	0,4	0,115	0,42	0,077	0,175	0,939	0,175	0,72	0,994	0	0,277	0,114	0,284	0,257	0,388	0,415	0,451	0,765	0,738	0,202	0,431	0,25	0,061	0,328	0,234
192	44	0,263	0,727	0,259	0,234	0,42	0,114	0,942	0,313	0,481	0,177	0,703	0,389	0,453	0,291	0	0,435	0,47	0,832	0,092	0,534	0,214	0,637	0,271	0,271	0,327	0,262	0,113	0,221	0,393
196	45	0,721	0,755	0,597	0,64	0,252	0,736	0,935	0,765	0,311	0,054	0,07	0,996	0,96	0,073	0,436	0	0,642	0,246	0,981	0,68	0,44	0,843	0,542	0,104	0,024	0,272	0,13	0,508	0,215
197	46	0,203	0,257	0,908	0,597	0,166	0,288	0,533	0,119	0,98	0,095	0,153	0,065	0,869	0,347	0,051	0,343	0	0,171	0,841	0,83	0,724	0,606	0,563	0,336	0,366	0,215	0,901	0,28	0,63
198	47	0,155	0,198	0,481	0,525	0,594	0,903	0,429	0,294	0,221	0,58	0,096	0,611	0,345	0,676	0,424	0,668	0,043	0	0,428	0,073	0,121	0,586	0,538	0,149	0,361	0,598	0,758	0,419	0,483
200	48	0,24	0,48	0,034	0,722	0,045	0,323	0,216	0,189	0,026	0,04	0,299	0,965	0,87	0,29	0,39	0,614	0,388	0,881	0	0,737	0,032	0,059	0,255	0,465	0,551	0,423	0,964	0,501	0,794
201	49	0,131	0,222	0,473	0,19	0,637	0,167	0,279	0,175	0,351	0,447	0,398	0,864	0,171	0,929	0,434	0,213	0,694	0,056	0,429	0	0,326	0,13	0,75	0,249	0,321	0,836	0,297	0,963	0,82
202	50	0,887	0,714	0,135	0,616	0,094	0,237	0,109	0,251	0,499	0,433	0,811	0,14	0,379	0,016	0,171	0,696	0,521	0,088	0,011	0,322	0	0,506	0,652	0,312	0,481	0,073	0,732	0,139	0,669
203	51	0,075	0,095	0,183	0,226	0,601	0,698	0,844	0,234	0,196	0,674	0,667	0,548	0,828	0,433	0,377	0,162	0,638	0,084	0,118	0,012	0,942	0	0,031	0,135	0,476	0,831	0,7	0,759	0,037
204	52	0,372	0,709	0,048	0,176	0,086	0,397	0,265	0,414	0,422	0,232	0,507	0,428	0,263	0,295	0,548	0,333	0,592	0,899	0,391	0,959	0,63	0,057	0	0,118	0,594	0,119	0,294	0,106	0,179
205	53	0,639	0,532	0,153	0,536	0,005	0,304	0,944	0,555	0,272	0,052	0,286	0,225	0,538	0,398	0,54	0,026	0,613	0,87	0,67	0,655	0,768	0,264	0,041	0	0,326	0,183	0,04	0,897	0,008
206	54	0,201	0,578	0,316	0,381	0,192	0,033	0,326	0,012	0,535	0,935	0,404	0,067	0,164	0,468	0,198	0,01	0,521	0,479	0,412	0,225	0,437	0,238	0,168	0,468	0	0,395	0,203	0,013	0,471
207	55	0,393	0,679	0,25	0,334	0,389	0,876	0,18	0,171	0,037	0,272	0,774	0,016	0,152	0,581	0,18	0,595	0,043	0,986	0,533	0,301	0,142	0,106	0,208	0,427	0,085	0	0,276	0,069	0,061
208	56	0,441	0,776	0,841	0,236	0,583	0,174	0,345	0,332	0,627	0,987	0,286	0,879	0,125	0,239	0,534	0,456	0,019	0,029	0,621	0,5	0,282	0,209	0,165	0,223	0,464	0,703	0	0,087	0,241
209	57	0,591	0,51	0,379	0,293	0,236	0,651	0,279	0,846	0,462	0,418	0,194	0,398	0,137	0,266	0,768	0,376	0,104	0,105	0,167	0,109	0,511	0,326	0,242	0,42	0,038	0,249	0,038	0	0,452
211	58	0,043	0,106	0,126	0,511	0,994	0,238	0,37	0,12	0,415	0,834	0,573	0,792	0,681	0,162	0,483	0,16	0,191	0,515	0,185	0,123	0,569	0,247	0,175	0,187	0,279	0,298	0,202	0,222	0
212	59	0,046	0,915	0,464	0,367	0,137	0,945	0,038	0,072	0,336	0,079	0,308	0,722	0,426	0,327	0,994	0,028	0,242	0,597	0,952	0,92	0,982	0,31	0,411	0,131	0,195	0,883	0,13	0,177	0,572
213	60	0,582	0,214	0,332	0,033	0,646	0,336	0,385	0,349	0,953	0,973	0,674	0,661	0,983	0,702	0,383	0,481	0,837	0,396	0,565	0,503	0,6	0,043	0,086	0,187	0,588	0,279	0,422	0,024	0,092
214	61	0,96	0,705	0,975	0,669	0,449	0,591	0,175	0,7	0,067	0,126	0,498	0,014	0,431	0,466	0,139	0,873	0,297	0,818	0,29	0,226	0,073	0,423	0,593	0,225	0,674	0,008	0,036	0,129	0,436
215	62	0,889	0,364	0,299	0,542	0,568	0,522	0,56	0,362	0,171	0,784	0,238	0,38	0,219	0,221	0,834	0,354	0,491	0,674	0,203	0,226	0,863	0,721	0,479	0,517	0,447	0,866	0,129	0,128	0,334
216	63	0,235	0,438	0,572	0,584	0,774	0,372	0,15	0,059	0,316	0,488	0,962	0,739	0,942	0,979	0,559	0,25	0,902	0,76	0,422	0,117	0,771	0,242	0,923	0,278	0,737	0,373	0,083	0,063	0,569
217	64	0,858	0,187	0,771	0,978	0,581	0,758	0,199	0,924	0,666	0,088	0,775	0,244	0,943	0,277	0,453	0,434	0,416	0,081	0,733	0,265	0,696	0,129	0,335	0,484	0,677	0,6	0,654	0,166	0,608
218	65	0,301	0,744	0,197	0,675	0,478	0,334	0,229	0,364	0,376	0,187	0,264	0,156	0,616	0,582	0,821	0,371	0,304	0,985	0,584	0,027	0,042	0,685	0,273	0,351	0,648	0,169	0,304	0,124	0,244
220	66	0,15	0,39	0,204	0,496	0,831	0,292	0,006	0,91	0,023	0,011	0,863	0,198	0,78	0,378	0,078	0,358	0,06	0,678	0,189	0,345	0,748	0,863	0,611	0,931	0,01	0,089	0,298	0,009	0,119
222	67	0,932	0,309	0,779	0,825	0,513	0,796	0,551	0,019	0,142	0,047	0,107	0,114	0,734	0,141	0,283	0,632	0,876	0,377	0,494	0,269	0,021	0,504	0,271	0,533	0,169	0,031	0,009	0,013	0,205
223	68	0,223	0,375	0,239	0,614	0,344	0,448	0,114	0,323	0,018	0,144	0,955	0,334	0,859	0,383	0,58	0,382	0,505	0,837	0,583	0,064	0,66	0,122	0,322	0,238	0,33	0,648	0,042	0,226	0,187
224	69	0,703	0,399	0,266	0,851	0,278	0,387	0,082	0,134	0,381	0,604	0,537	0,436	0,101	0,126	0,123	0,797	0,037	0,219	0,469	0,212	0,367	0,389	0,259	0,117	0,924	0,653	0,116	0,049	0,314
225	70	0,229	0,543	0,51	0,645	0,217	0,706	0,955	0,555	0,682	0,177	0,211	0,831	0,007	0,274	0,852	0,87	0,924	0,33	0,534	0,729	0,483	0,438	0,103	0,061	0,659	0,231	0,049	0,158	0,115
230	71	0,195	0,492	0,055	0,335	0,248	0,01	0,033	0,144	0,17	0,24	0,126	0,72	0,534	0,164	0,092	0,08	0,211	0,903	0,535	0,103	0,079	0,338	0,561	0,24	0,248	0,873	0,205	0,682	0,254
231	72	0,253	0,382	0,645	0,948	0,283	0,612	0,522	0,766	0,021	0,562	0,289	0,28	0,468	0,55	0,123	0,875	0,774	0,225	0,741	0,277	0,776	0,31	0,14	0,497	0,247	0,628	0,462	0,079	0,416
300	73	0,038	0,315	0,322	0,376	0,485	0,198	0,019	0,237	0,016	0,609	0,889	0,703	0,194	0,883	0,661	0,438	0,457	0,225	0,338	0,446	0,854	0,396	0,684	0,751	0,097	0,273	0,002	0,366	0,536
301	74	0,658	0,76	0,301	0,915	0,238	0,707	0,2	0,151	0,072	0,261	0,317	0,145	0,261	0,079	0,381	0,839	0,873	0,856	0,549	0,059	0,419	0,365	0,075	0,366	0,412	0,044	0,183	0,16	0,326
302	75	0,324	0,585	0,263	0,429	0,286	0,687	0,094	0,388	0,109	0,331	0,661	0,803	0,444	0,141	0,154	0,024	0,132	0,749	0,137	0,864	0,042	0,511	0,379	0,065	0,187	0,18	0,635	0,549	0,352
303	76	0,5	0,409	0,83	0,661	0,692	0,272	0,305	0,022	0,127	0,41	0,382	0,691	0,026	0,085	0,484	0,462	0,115	0,994	0,055	0,502	0,136	0,302	0,622	0,57	0,285	0,103	0,056	0,275	0,27
304	77	0,798	0,364	0,515	0,864	0,698	0,831	0,779	0,256	0,014	0,271	0,483	0,366	0,686	0,193	0,581	0,293	0,208	0,22	0,045	0,683	0,006	0,678	0,811	0,642	0,289	0,129	0,171	0,093	0,68
501	78	0,352	0,485	0,477	0,758	0,068	0,269	0,912	0,88	0,704	0,298	0,894	0,281	0,274	0,049	0,24	0,129	0,92	0,604	0,837	0,593	0,242	0,555	0,056	0,05	0,91	0,144	0,436	0,531	0,095
502	79	0,352	0,485	0,477	0,758	0,068	0,269	0,912	0,88	0,704	0,298	0,894	0,281	0,274	0,049	0,24	0,129	0,92	0,604	0,837	0,593	0,242	0,555	0,056	0,05	0,91	0,144	0,436	0,531	0,095
503	80	0,352	0,485	0,477	0,758	0,068	0,269	0,912	0,88	0,704	0,298	0,894	0,281	0,274	0,049	0,24	0,129	0,92	0,604	0,837	0,593	0,242	0,555	0,056	0,05	0,91	0,144	0,436	0,531	0,095
504	81	0,401	0,87	0,625	0,473	0,035	0,319	0,484	0,927	0,636	0,186	0,738	0,151	0,283	0,472	0,511	0,819	0,66	0,866	0,912	0,233	0,286	0,563	0,299	0,083	0,718	0,567	0,938	0,07	0,227
505	82	0,401	0,87	0,625	0,473	0,035	0,319	0,484	0,927	0,636	0,186	0,738	0,151	0,283	0,472	0,511	0,819	0,66	0,866	0,912	0,233	0,286	0,563	0,299	0,083	0,718	0,567	0,938	0,07	0,227
506	83	0,352	0,485	0,477	0,758	0,068	0,269	0,912	0,88	0,704	0,298	0,894	0,281	0,274	0,049	0,24	0,129	0,92	0,604	0,837	0,593	0,242	0,555	0,056	0,05	0,91	0,144	0,436	0,531	0,095
507	84	0,352	0,485	0,477	0,758	0,068	0,269	0,912	0,88	0,704	0,298	0,894	0,281	0,274	0,049	0,24	0,129	0,92	0,604	0,837	0,593	0,242	0,555	0,056	0,05	0,91	0,144	0,436	0,531	0,095
508	85	0,352	0,485	0,477	0,758	0,068	0,269	0,912	0,88	0,704	0,298	0,894	0,281	0,274	0,049	0,24	0,129	0,92	0,604	0,837	0,593	0,242	0,555	0,056	0,05	0,91	0,144	0,436	0,531	0,095
509	86	0,371	0,946	0,662	0,45	0,045	0,191	0,172	0,684	0,329	0,316	0,734	0,09	0,477	0,75	0,69	0,849	0,648	0,743	0,929	0,146	0,41	0,432	0,409	0,116	0,306	0,71	0,855	0,056	0,363
510	87	0,153	0,299	0,262	0,129	0,343	0,006	0,106	0,441	0,073	0,946	0,73	0,918	0,701	0,905	0,387	0,447	0,774	0,403	0,53	0,087	0,685	0,239	0,337	0,731	0,053	0,961	0,354	0,528	0,764
511	88	0,044	0,861	0,424	0,512	0,806	0,343	0,056	0,131	0,156	0,955	0,806	0,79	0,709	0,821	0,787	0,189	0,736	0,726	0,603	0,25	0,65	0,219	0,551	0,364	0,486	0,219	0,027	0,245	0,219
512	89	0,521	0,837	0,609	0,624	0,269	0,343	0,254	0,412	0,272	0,325	0,803	0,038	0,726	0,728	0,933	0,71	0,258	0,414	0,877	0,488	0,695	0,314	0,297	0,165	0,128	0,675	0,455	0,047	0,398
513	90	0,767	0,814	0,159	0,323	0,069	0,727	0,098	0,94	0,535	0,213	0,319	0,375	0,145	0,059	0,771	0,583	0,421	0,63	0,261	0,41	0,004	0,585	0,181	0,341	0,795	0,383	0,414	0,066	0,17
514	91	0,322	0,475	0,319	0,37	0,673	0,529	0,987	0,315	0,851	0,427	0,783	0,096	0,199	0,631	0,496	0,245	0,083	0,44	0,149	0,705	0,497	0,124	0,161	0,217	0,056	0,456	0,362	0,413	0,224
516	93	0,371	0,946	0,662	0,45	0,045	0,191	0,172	0,684	0,329	0,316	0,734	0,09	0,477	0,75	0,69	0,849	0,648	0,743	0,929	0,146	0,41	0,432	0,409	0,116	0,306	0,71	0,855	0,056	0,363
517	94	0,731	0,941	0,169	0,688	0,079	0,395	0,712	0,941	0,965	0,096	0,499	0,372	0,207	0,173	0,068	0,161	0,636	0,667	0,908	0,554	0,032	0,667	0,18	0,122	0,93	0,401	0,675	0,13	0,127
518	95	0,347	0,133	0,828	0,907	0,253	0,121	0,612	0,834	0,315	0,948	0,84	0,412	0,541	0,104	0,611	0,186	0,613	0,711	0,965	0,604	0,235	0,652	0,104	0,335	0,936	0,14	0,673	0,378	0,917
519	96	0,352	0,485	0,477	0,758	0,068	0,269	0,912	0,88	0,704	0,298	0,894	0,281	0,274	0,049	0,24	0,129	0,92	0,604	0,837	0,593	0,242	0,555	0,056	0,05	0,91	0,144	0,436	0,531	0,095
520	97	0,134	0,678	0,395	0,24	0,071	0,066	0,504	0,492	0,558	0,436	0,8	0,383	0,616	0,273	0,163	0,329	0,943	0,875	0,769	0,054	0,446	0,359	0,541	0,155	0,429	0,726	0,871	0,412	0,077
521	98	0,111	0,07	0,124	0,421	0,478	0,772	0,309	0,596	0,184	0,704	0,978	0,641	0,745	0,649	0,161	0,495	0,248	0,606	0,017	0,227	0,368	0,071	0,605	0,586	0,318	0,365	0,184	0,682	0,119
522	99	0,228	0,349	0,09	0,29	0,138	0,834	0,777	0,49	0,592	0,286	0,715	0,505	0,121	0,73	0,515	0,464	0,379	0,903	0,012	0,859	0,671	0,115	0,206	0,37	0,621	0,576	0,052	0,994	0,053
523	100	0,168	0,795	0,601	0,458	0,742	0,583	0,19	0,029	0,373	0,749	0,656	0,749	0,968	0,89	0,54	0,079	0,796	0,889	0,425	0,313	0,774	0,183	0,682	0,282	0,697	0,389	0,043	0,266	0,358
524	101	0,537	0,674	0,553	0,621	0,604	0,369	0,223	0,426	0,274	0,239	0,277	0,073	0,802	0,737	0,766	0,469	0,314	0,999	0,687	0,041	0,062	0,672	0,461	0,25	0,677	0,1	0,17	0,173	0,248
525	102	0,566	0,257	0,976	0,713	0,427	0,688	0,052	0,364	0,896	0,452	0,337	0,548	0,51	0,805	0,792	0,593	0,586	0,391	0,971	0,472	0,848	0,228	0,287	0,602	0,837	0,635	0,865	0,199	0,815
527	104	0,01	0,036	0,526	0,249	0,424	0	0,167	0,127	0,019	0,042	0,212	0,805	0,712	0,349	0,189	0,203	0,168	0,409	0,436	0,052	0,896	0,228	0,313	0,658	0,09	0,574	0,783	0,758	0,707
528	105	0,937	0,79	0,243	0,308	0,059	0,63	0,021	0,845	0,93	0,189	0,381	0,36	0,543	0,328	0,367	0,397	0,827	0,51	0,476	0,291	0,019	0,548	0,691	0,278	0,555	0,806	0,239	0,055	0,173
529	106	0,004	0,276	0,911	0,199	0,923	0,125	0,149	0,021	0,107	0,048	0,889	0,476	0,42	0,929	0,847	0,338	0,351	0,834	0,786	0,293	0,697	0,362	0,597	0,656	0,351	0,519	0,165	0,792	0,625
530	107	0,272	0,028	0,565	0,665	0,545	0,378	0,05	0,01	0,234	0,711	0,322	0,722	0,014	0,124	0,845	0,494	0,421	0,382	0,724	0,443	0,109	0,435	0,183	0,788	0,162	0,259	0,216	0,391	0,241
531	108	0,151	0,748	0,418	0,216	0,027	0,086	0,505	0,537	0,662	0,376	0,602	0,383	0,489	0,211	0,164	0,36	0,975	0,868	0,83	0,099	0,338	0,374	0,372	0,091	0,589	0,64	0,689	0,178	0,078
600	109																													
601	110																													

x<=0,05	4	11	1	4	3	7	9	3	10	5	11	20	2	15	4	1	15	8	4	4	4	5	3	2	2	0	8	7	3
0,1=>x>0,05	13	7	7	13	4	16	14	6	9	7	17	9	6	11	13	6	9	9	6	6	6	12	4	8	3	1	5	13	1
x<=0,05	7	6	8	3	4	7	7	13	3	6	10	3	7	1	3	1	3	7	3	2	0	7	6	3	0	0	7	1	7
0,1=>x>0,05	11	7	8	2	5	6	9	5	5	5	8	2	7	8	2	3	6	11	1	12	3	3	8	2	4	4	13	8	3

x<=0,05	12	7	3	3	8	6	11	7	14	14	0	4	3	12	0	4	5	2	6	6	10	4	2	8	6	5	14	7	4
0,1=>x>0,05	4	4	7	0	14	4	7	7	7	7	4	7	1	7	7	5	5	4	4	11	7	5	13	6	12	6	9	17	13
x<=0,05	12	5	4	6	1	8	8	9	7	7	1	3	0	3	4	1	0	1	10	0	8	8	5	11	10	5	5	2	3
0,1=>x>0,05	8	3	5	6	3	9	8	7	10	8	2	3	5	8	8	4	4	5	3	3	8	10	7	8	5	5	7	9	6

SUM	Q	2	3	4	5	9	13	21	22	23	24	30	31	32	33	36	37	39	42	46	146	147	149	150	152	155	156	158	159	160
x>80		11	17	9	7	7	14	16	16	13	11	21	23	9	16	7	2	18	15	7	6	4	12	9	5	2	0	15	8	10
80>x>77		24	14	15	15	9	22	23	11	14	12	25	11	13	19	15	9	15	20	7	18	9	15	12	10	7	5	18	21	4
		35	31	24	22	16	36	39	27	27	23	46	34	22	35	22	11	33	35	14	24	13	27	21	15	9	5	33	29	14

SUM	Q	162	163	167	169	170	174	175	176	177	179	180	186	188	190	192	196	197	198	200	201	202	203	204	205	206	207	208	209	211
x>80		24	12	7	9	9	14	19	16	21	21	1	7	3	15	4	5	5	3	16	6	18	12	7	19	16	10	19	9	7
80>x>77		12	7	12	6	17	13	15	14	17	15	6	10	6	15	15	9	9	9	7	14	15	15	20	14	17	11	16	26	19
		36	19	19	15	26	27	34	30	38	36	7	17	9	30	19	14	14	12	23	20	33	27	27	33	33	21	35	35	26

Q2	Q1	K-W: p	N	M	Sense?	ME Plot	Regressie P	R²	FL Plot	Definite?	Final	Check	reason	Q2 in the AEM?	Q1 in the AEM?
21	220	0,082	ok	ok	interesting	doubtful	0,092	6,80%	doubtful	doubtful	add corr line	x	correlation	1	1
22	220	0,026	ok	ok	interesting	doubtful	0	34,30%	doubtful	doubtful	add corr line		correlation	1	1
22	222	0,042	ok	ok	interesting	doubtful	0	34,30%	doubtful	doubtful	add corr line		correlation	1	1
23	36	0,023	ok	ok						ok	add corr line		correlation	1	0
24	37	0,058	ok	ok						ok	add 37 with correlated line 24; add 24 to 528		correlation	0	0
33	196	0,077	ok	ok	interesting					doubtful	add corr line		correlation	1	0
33	202	0,077	ok	ok	interesting					doubtful	add corr line		correlation	1	0
36	23	0,039	ok	ok						ok	add corr line		correlation	0	1
46	190	0,036	ok	ok	interesting					doubtful	add corr line (apart from the rest)		correlation	0	0
146	177	0,083	ok	ok	interesting					doubtful	in the model already		correlation	1	1
146	223	0,019	ok	ok	interesting	ok	0,003	22,70%	doubtful	ok	move 177 to 520		no real correlation	1	1
158	160	0,009	ok	ok	interesting					doubtful	move 158 to 829; add corr.line 160-158		correlation	1	1
158	529	0,009	ok	ok	ok	doubtful	0,006	19,10%	doubtful	ok	move 158 to 829; add corr.line 160-158		correlation	1	1
159	158	0,082	ok	ok						ok	move 159 to 529; add corr.line 158-159		correlation	1	1
501	204	0,056	ok	ok	ok	ok	ok	ok	ok	ok	in the model already		correlation	1	1
501	205	0,05	ok	ok	ok	ok	ok	ok	ok	ok	in the model already		correlation	1	1
174	179	0,042	ok	ok	interesting					ok	in the model already		correlation	1	1
174	230	0,074	ok	ok	interesting	ok	0,001	36,60%	ok	doubtful	add corr line		correlation	1	0
175	206	0,002	ok	ok	interesting					doubtful	add corr line		correlation	1	0
175	230	0,062	ok	ok	interesting	ok	0	44,10%	ok	ok	add corr line		correlation	1	0
175	231	0,019	ok	ok	ok	ok	0,233	2,50%	ok	ok	add corr line		correlation	1	0
175	529	0,058	ok	ok	interesting	doubtful	0,021	12,60%	doubtful	doubtful	add corr line		correlation	1	1
176	523	0,067	ok	ok	interesting	ok	0,024	12,70%	no	doubtful	add corr line		correlation	1	1
177	162	0,003	ok	ok	interesting					doubtful	add corr line		correlation	1	1
177	174	0,08	ok	ok	interesting					doubtful	add corr line		correlation	1	1
177	179	0,033	ok	ok	interesting					doubtful	add normal line		causal relation	1	1
177	300	0,022	ok	ok	interesting	doubtful	0,431	0%	ok	ok	add corr line		correlation	1	1
177	527	0,08	ok	ok	ok	ok	0,001	22,70%	doubtful	doubtful	add normal line		correlation	1	1
186	36	0,067	ok	ok						ok	add corr line		correlation	1	0
198	201	0,073	ok	ok	interesting					doubtful	add corr line (apart from the rest)		correlation	0	0
202	39	0,012	ok	ok	interesting					doubtful	add corr line		correlation	0	1
202	207	0,073	ok	ok	interesting					doubtful	add corr line (apart from the rest)		correlation	0	0
202	222	0,072	ok	ok	interesting	doubtful	0,006	22,00%	doubtful	doubtful	add corr line		correlation	0	1
205	31	0,043	ok	ok						ok	add corr line		correlation	1	0
207	30	0,056	ok	ok						doubtful	add corr line (apart from the rest)		correlation	0	0
207	222	0,048	ok	ok	interesting	ok	0,005	28,10%	ok	ok	add corr line		correlation	0	1
213	30	0,011	ok	ok						doubtful	add corr line		correlation	1	0
213	217	0,069	ok	ok	interesting					doubtful	add corr line		correlation	1	1
222	32	0,057	ok	ok						ok	in the model already		correlation	1	1
222	202	0,021	ok	ok	interesting					doubtful	add corr line		correlation	1	0
222	214	0,048	ok	ok	interesting					doubtful	add corr line		correlation	1	1
223	30	0,084	ok	ok						ok	add corr line		correlation	1	0
223	301	0,053	ok	ok	interesting	doubtful	0,004	24,50%	doubtful	doubtful	add corr line		correlation	1	0
224	2	0,009	no	ok						doubtful	add corr line		correlation	0	0
224	209	0,049	ok	ok	interesting					doubtful	add corr line (apart from the rest)		correlation	0	1
230	174	0,01	ok	ok	interesting					doubtful	add corr line		correlation	0	1
230	175	0,033	ok	ok	interesting					doubtful	add corr line		correlation	0	1
230	527	0,01	ok	ok	ok	ok	0,001	36,60%	doubtful	doubtful	add corr line		correlation	0	1
300	177	0,016	ok	ok	interesting					doubtful	add corr line		correlation	1	1
301	214	0,017	ok	ok	interesting					doubtful	add corr line		correlation	0	1
301	222	0,055	ok	ok	interesting	ok	0,001	33,20%	ok	ok	add corr line		correlation	0	1
302	30	0,027	ok	ok						doubtful	add corr line		correlation	1	0
302	146	0,057	ok	ok						ok	add corr line		correlation	1	1
302	304	0,04	ok	ok	interesting	ok	0,021	13%	doubtful	ok	add corr line		correlation	1	0
304	21	0,088	ok	ok						ok	add corr line		correlation	0	1
304	202	0,006	ok	ok	interesting					doubtful	add corr line		correlation	0	0
511	208	0,027	ok	ok	interesting					doubtful	add corr line		correlation	1	1
511	529	0,046	ok	ok	interesting	doubtful	0	36,40%	doubtful	doubtful	add corr line		correlation	1	1
513	146	0,085	ok	ok						ok	add corr line		correlation	1	1
513	224	0,014	ok	ok	interesting	ok	0	37%	ok	ok	add corr line		correlation	1	0
517	224	0,034	ok	ok	interesting	ok	0	30,70%	ok	ok	add corr line		correlation	1	0
519	30	0,097	ok	ok						doubtful	add corr line		correlation	1	0
521	23	0,007	ok	ok						ok	add corr line		correlation	1	1
528	224	0,007	ok	ok	interesting	ok	0	36,10%	ok	ok	add corr line		correlation	1	0
531	201	0,099	ok	ok	interesting					doubtful	add corr line		correlation	1	0

Appendix L.

Explanation of the input factor relations

Table L.1: *Explanation of the obtained input factor relations*

F 1	Description	F 2	Description	Explanation of the relation
220	Quality of BAD/SAD	21	BAD/SAD discussed with business	When the BAD/SAD is discussed with the business, the quality of the BAD/SAD increases
220	Quality of BAD/SAD	22	BAD/SAD documents review	If BAD/SAD review is higher, its quality increases
222	Initial BAD/SAD compliance to DA	22	BAD/SAD documents review	When the review of the BAD/SAD documents is higher, the initial BAD/SAD compliance is larger
36	# meetings of EA with project team during FMI	23	Involvement of EA in FMI	More enterprise architect meetings lead to more enterprise architect involvement
37	# meetings of BA with project team during FMI	24	Involvement of BA in FMI	More business architect meetings lead to more business architect involvement
196	Business value increase	33	BAD compliance to BA	BAD compliance to BA correlates with higher business value
202	Potential decrease of costs for future projects	33	BAD compliance to BA	A higher BAD compliance to BA correlates with a potential decrease of costs for future projects
23	Involvement of EA in FMI	36	# meetings of EA with project team during FMI	More enterprise architect meetings lead to more enterprise architect involvement

F 1	Description	F 2	Description	Explanation of the relation
190	Alignment of the domain with BA	46	Feedback from impl. team incorporated in business arch.	Incorporation of impl. team feedback in BA leads to domain alignment with BA
177	Quality of technical requirements	146	Technical complexity	When the quality of technical requirements is low, the technical complexity increases
223	Business complexity	146	Technical complexity	High business complexity projects involve high technical complexity and vice versa
160	PM Progress measurement	158	Change management in the process by PM	Progress measurement involves change management
529	PM Skills	158	Change management in the process by PM	PM skills involve change management
158	Change management in the process by PM	159	Code quality management & testing by PM	Both factors are high when there is a skilled PM
204	Delivered generic services	501	Architectural building blocks	High influence of architecture in the project leads to the delivery of generic services
205	Reuse of (in the past) delivered generic services	501	Architectural building blocks	High influence of architecture in the project leads to the reuse of generic services
179	Project proposal review	174	Quality of functional specifications	Profound PP review leads to higher quality of functional specifications
230	Business value of functional requirements	174	Quality of functional specifications	The quality of functional specifications is influenced by the business value
206	Percentage of delivered functionality	175	Clarity of acceptance requirements	When the acceptance requirements are clear, the delivered functionality is higher
230	Business value of functional requirements	175	Clarity of acceptance requirements	A higher business value leads to more clarity of acceptance criteria

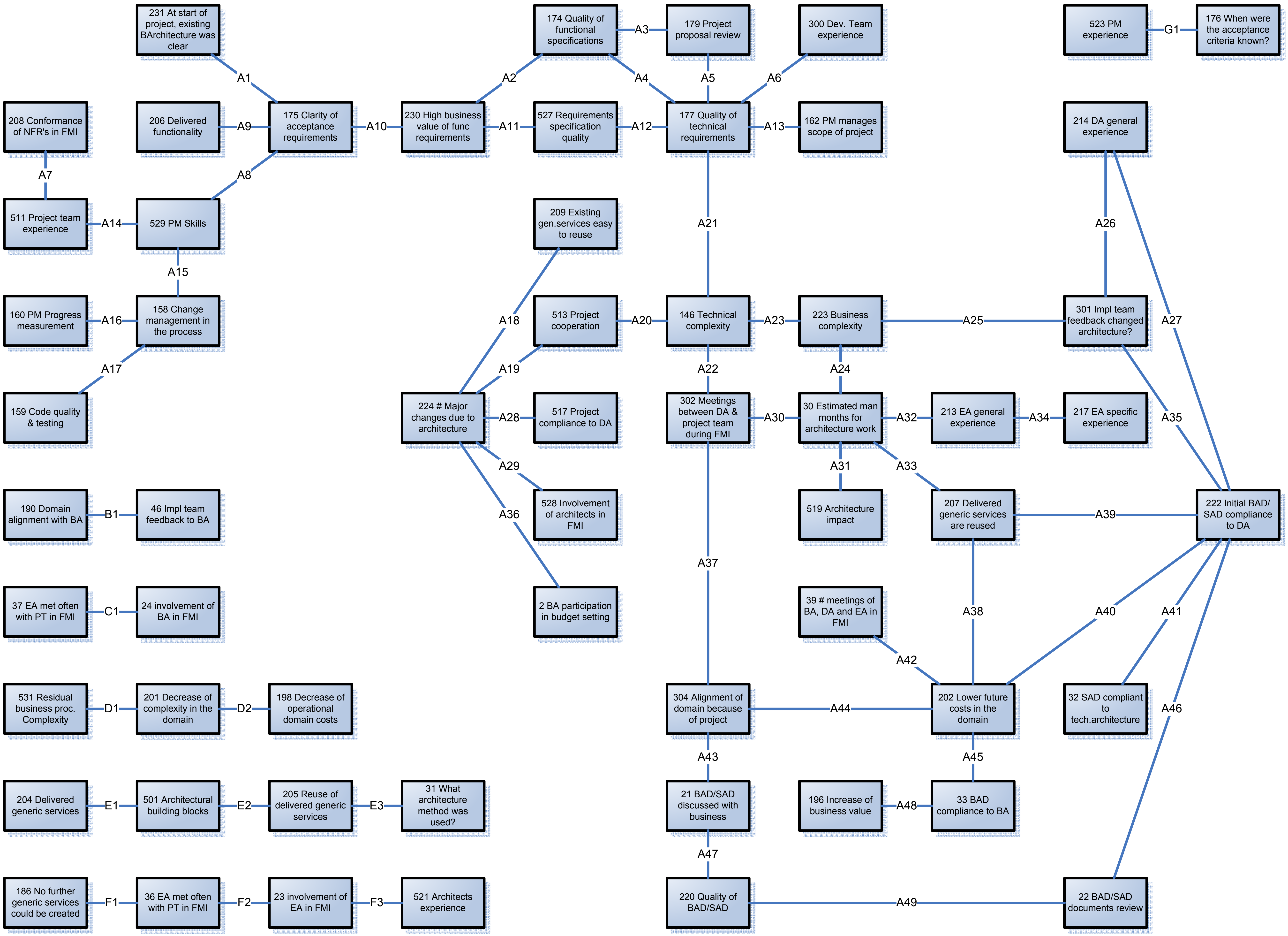
F 1	Description	F 2	Description	Explanation of the relation
231	There was a pre-documented BA at start of project	175	Clarity of acceptance requirements	The existence of a pre-documented BA leads to more clarity of the acceptance requirements
529	PM Skills	175	Clarity of acceptance requirements	A skilled PM leads to a better acceptance criteria specifications
523	PM experience	176	When were the acceptance criteria known?	A experienced PM leads to a better acceptance criteria specification
162	PM manages scope of project	177	Quality of technical requirements	A PM that manages the project well ensures high quality of technical requirements
174	Quality of functional specifications	177	Quality of technical requirements	High quality of functional requirements is related to high quality of technical requirements and vice versa
179	Project proposal review	177	Quality of technical requirements	A profound project proposal review leads to high quality of technical requirements
300	Dev. Team experience	177	Quality of technical requirements	This relation seems to be based on the fact that when the development phase happened in an orderly fashion, the interviewee considers both aspects of the development phase positive
527	Functional requirements specification quality	177	Quality of technical requirements	A good project proposal leads to high quality of functional and technical requirements
36	# meetings of EA with project team during FMI	186	No further generic services could be created	High cooperation of project team and EA lead to creation of generic services
201	Decrease of complexity in the domain	198	Decrease of operational cost in the domain	Decrease of complexity in the domain leads to decrease of operational cost in the domain
39	# meetings of BA, DA and EA in FMI	202	Decrease of future costs in the domain caused by the project	The number of architect meetings lead to a decrease of operational costs in the domain

F 1	Description	F 2	Description	Explanation of the relation
207	Reuse of delivered generic services by other projects	202	Decrease of future costs in the domain caused by the project	Reuse of delivered services by other projects leads to a decrease in future project costs
222	Initial BAD/SAD compliance to DA	202	Decrease of future costs in the domain caused by the project	When the project is (from the start) compliant to the BAD/SAD, the future costs in the domain will decrease
30	Estimated man months of architecture work	207	Reuse of delivered generic services by other projects	The more work on architecture, the better the quality of the generic services. Therefore, it is likely that these generic services will be reused
222	Initial BAD/SAD compliance to DA	207	Reuse of delivered generic services by other projects	When there is a high BAD/SAD compliance to DA, the reuse of delivered generic services by other projects is more probable. This can be explained by the fact that these produced services have a better quality
30	Estimated man months of architecture work	213	EA general experience	The more experience an enterprise architect has, the less man months on architecture it takes. An experienced architect uses the hours on architecture more effective
217	EA specific experience	213	EA general experience	A skilled enterprise architect has a broad experience
32	SAD compliant to tech.architecture	222	Initial BAD/SAD compliance to DA	The technical architecture is part of the domain architecture
214	DA general experience	222	Initial BAD/SAD compliance to DA	An experienced domain architect will ensure a high initial BAD/SAD compliance
30	Estimated man months of architecture work	223	Business complexity	Decrease of complexity in the domain leads to decrease of operational cost in the domain

F 1	Description	F 2	Description	Explanation of the relation
301	Implementation team feedback incorporated in the Domain Architecture?	223	Business complexity	When there was a high business complexity, the risks for future project was minimized by incorporating the implementation team feedback in the DA
2	Involvement of business architect in setting the budget for the project	224	# major changes in the design that decreased project cost because of architecture	Involvement of business architect in budget setting leads to project changes that decrease project costs
209	Existing gen. services easy to reuse	224	# major changes in the design that decreased project cost because of architecture	When the existing generic services are easy to reuse, less changes in the project design are needed
527	Functional requirements specification quality	230	Business value of functional requirements	The business value influences the quality of functional specifications
177	Quality of technical requirements	300	Dev. Team experience	This relation seems to be based on the fact that when the development phase happened in an orderly fashion, the interviewee considers both aspects of the development phase positive
214	DA general experience	301	Level of incorporation of implementation team feedback in Domain Architecture	An experienced domain architect will ensure a high level of incorporation of implementation team feedback into domain architecture
222	Initial BAD/SAD compliance to DA	301	Level of incorporation of implementation team feedback in Domain Architecture	This correlation can be explained by considering that a well managed project has both compliancy to the DA as well as the incorporation of implementation team feedback

F 1	Description	F 2	Description	Explanation of the relation
30	Estimated man months of architecture work	302	# meetings between DA & project team during FMI	# meetings of DA & project team influences the estimated man months on architecture work
146	Technical complexity	302	# meetings between DA & project team during FMI	A high technical project complexity leads to many DA & project team meetings in FMI phase
304	Alignment of the domain with EA	302	# meetings between DA & project team during FMI	A high DA alignment with EA leads to an architecture policy in which the DA and project team have many meetings during FMI phase
21	BAD/SAD discussed with business	304	Alignment of the domain with EA	A high DA alignment with EA leads to an architecture policy in which the BAD/SAD is extensively discussed with the business
202	Decrease of future costs in the domain caused by the project	304	Alignment of the domain with EA	When the project is executed in a domain that is highly aligned with EA, the future costs in the domain will decrease
208	Conformance of NFR's in FMI	511	Project team experience	The trend here is that a high project team experience leads to a lower conformance of NFR's. This can be explained by the fact that an experienced project team does not obey the NFR's
529	PM Skills	511	Project team experience	The PM is part of the project team; therefore these are related
146	Technical complexity	513	Project cooperation	A high technical complexity leads to a lot of project cooperation
224	# major changes in the design that decreased project cost because of architecture	513	Project cooperation	A high project cooperation leads to more changes in the design that decreased the project cost

F 1	Description	F 2	Description	Explanation of the relation
224	# major changes in the design that decreased project cost because of architecture	517	Project compliance to DA	A high project compliance to the DA leads to more changes in the project design that decrease costs
30	Estimated man months of architecture work	519	Architecture worth	The worth of architecture increases when more months of architecture work is involved
23	Involvement of EA in FMI	521	Architects experience	The trend here is that a higher experience of the architects involved in a project leads to a lower involvement of the enterprise architect in FMI phase
224	# major changes in the design that decreased project cost because of architecture	528	Involvement of architects in FMI	A higher involvement of the architects in FMI phase leads to more changes in the design that decrease the project costs
201	Decrease of complexity in the domain	531	Residual functional complexity	A decrease of complexity in the domain leads to lower functional complexity


231 At start of project, existing BArchitecture was clear
174 Quality of functional specifications
179 Project proposal review
300 Dev. Team experience
523 PM experience
176 When were the acceptance criteria known?
208 Conformance of NFR's in FMI
206 Delivered functionality
175 Clarity of acceptance requirements
230 High business value of func requirements
527 Requirements specification quality
177 Quality of technical requirements
162 PM manages scope of project
214 DA general experience
511 Project team experience
529 PM Skills
209 Existing gen.services easy to reuse
160 PM Progress measurement
158 Change management in the process
513 Project cooperation
146 Technical complexity
223 Business complexity
301 Impl team feedback changed architecture?
159 Code quality & testing
224 # Major changes due to architecture
517 Project compliance to DA
302 Meetings between DA & project team during FMI
30 Estimated man months for architecture work
213 EA general experience
217 EA specific experience
190 Domain alignment with BA
46 Impl team feedback to BA
528 Involvement of architects in FMI
519 Architecture impact
207 Delivered generic services are reused
222 Initial BAD/ SAD compliance to DA
37 EA met often with PT in FMI
24 involvement of BA in FMI
2 BA participation in budget setting
39 # meetings of BA, DA and EA in FMI
531 Residual business proc. Complexity
201 Decrease of complexity in the domain
198 Decrease of operational domain costs
304 Alignment of domain because of project
202 Lower future costs in the domain
32 SAD compliant to tech.architecture
204 Delivered generic services
501 Architectural building blocks
205 Reuse of delivered generic services
31 What architecture method was used?
21 BAD/SAD discussed with business
196 Increase of business value
33 BAD compliance to BA
186 No further generic services could be created
36 EA met often with PT in FMI
23 involvement of EA in FMI
521 Architects experience
220 Quality of BAD/SAD
22 BAD/SAD documents review
A1
A2
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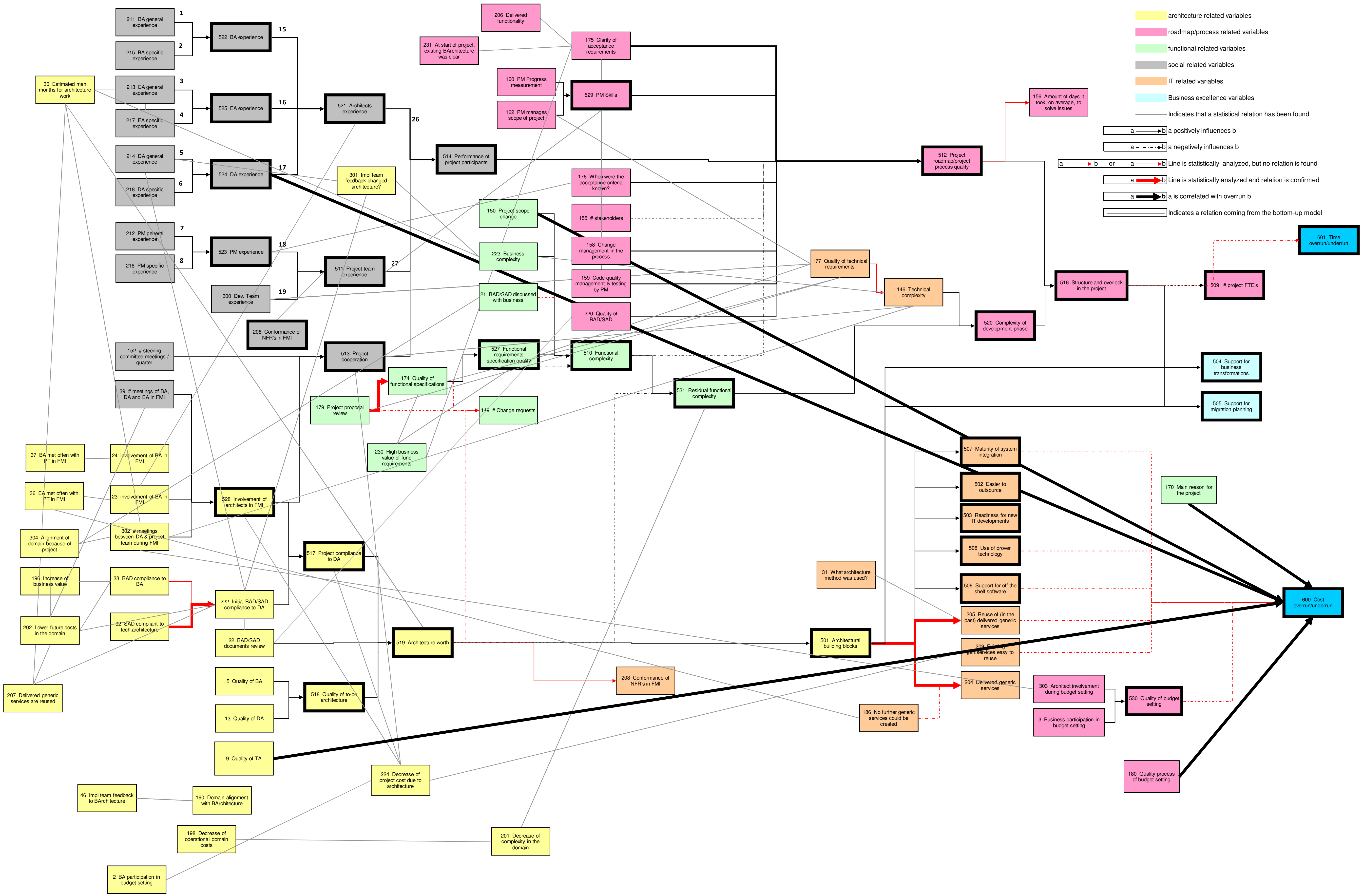
F2
F3


architecture related variables
roadmap/process related variables
functional related variables
social related variables
IT related variables
Business excellence variables
Indicates that a statistical relation has been found
a positively influences b
a negatively influences b
Line is statistically analyzed, but no relation is found
Line is statistically analyzed and relation is confirmed
a is correlated with overrun b
Indicates a relation coming from the bottom-up model
211 BA general experience
215 BA specific experience
213 EA general experience
217 EA specific experience
214 DA general experience
218 DA specific experience
212 PM general experience
216 PM specific experience
30 Estimated man months for architecture work
522 BA experience
525 EA experience
524 DA experience
523 PM experience
300 Dev. Team experience
521 Architects experience
511 Project team experience
208 Conformance of NFR's in FMI
513 Project cooperation
514 Performance of project participants
301 Impl team feedback changed architecture?
152 # steering committee meetings / quarter
39 # meetings of BA, DA and EA in FMI
37 BA met often with PT in FMI
36 EA met often with PT in FMI
24 involvement of BA in FMI
23 involvement of EA in FMI
302 # meetings between DA & project team during FMI
304 Alignment of domain because of project
196 Increase of business value
202 Lower future costs in the domain
207 Delivered generic services are reused
33 BAD compliance to BA
32 SAD compliant to tech.architecture
528 Involvement of architects in FMI
222 Initial BAD/SAD compliance to DA
22 BAD/SAD documents review
5 Quality of BA
13 Quality of DA
9 Quality of TA
517 Project compliance to DA
518 Quality of to-be architecture
519 Architecture worth
224 Decrease of project cost due to architecture
46 Impl team feedback to BArchitecture
190 Domain alignment with BArchitecture
198 Decrease of operational domain costs
2 BA participation in budget setting
201 Decrease of complexity in the domain
206 Delivered functionality
231 At start of project, existing BArchitecture was clear
175 Clarity of acceptance requirements
160 PM Progress measurement
162 PM manages scope of project
529 PM Skills
176 When were the acceptance criteria known?
155 # stakeholders
158 Change management in the process
159 Code quality management & testing by PM
220 Quality of BAD/SAD
150 Project scope change
223 Business complexity
21 BAD/SAD discussed with business
527 Functional requirements specification quality
510 Functional complexity
174 Quality of functional specifications
179 Project proposal review
149 # Change requests
230 High business value of func requirements
531 Residual functional complexity
208 Conformance of NFR's in FMI
177 Quality of technical requirements
146 Technical complexity
512 Project roadmap/project process quality
156 Amount of days it took, on average, to solve issues
520 Complexity of development phase
516 Structure and overlook in the project
509 # project FTE's
601 Time overrun/underrun
504 Support for business transformations
505 Support for migration planning
507 Maturity of system integration
502 Easier to outsource
503 Readiness for new IT developments
508 Use of proven technology
506 Support for off the shelf software
205 Reuse of (in the past) delivered generic services
209 Existing gen.services easy to reuse
204 Delivered generic services
31 What architecture method was used?
501 Architectural building blocks
186 No further generic services could be created
303 Architect involvement during budget setting
3 Business participation in budget setting
530 Quality of budget setting
170 Main reason for the project
600 Cost overrun/underrun
180 Quality process of budget setting

Colophon

THIS thesis was typeset by the author with the LaTeX 2ε Documentation System on an Lenovo notebook computer running Microsoft Windows Vista. Text editing was done in LyX using the MikTeX package. The illustrations and graphs were created with Microsoft Visio 2007 and Microsoft Excel 2007. The front cover illustration is an illustration by Gideon Bouma. The body type is 11 point. Chapter and section titles are in various sizes of Adobe Helvetica-Narrow Bold. The following additional software has been used:

Freemind version 0.8.1

Minitab Statistical Software 14

Minitab Statistical Software 15

Lotus Notes version 7

Foxit Reader Version 2.2