Aalto University
School of Business

The Business Value of Good Quality in Information Systems

Information Systems Science

Master's thesis

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2014

Department of Information and Service Economy
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Master's Thesis
Eero Talonen
4 June 2014
Information and Service Economy

Approved in the Department of Information and Service Economics _____
and awarded the grade _____

_____ _____

1st inspector's first name family name 2nd inspector's first name family name

AALTO UNIVERSITY SCHOOL OF ECONOMICS
Department of Information and Service Economy

ABSTRACT OF
MASTER'S THESIS

Author: Eero Talonen

Title of thesis: The Business Value of Good Quality in Information Systems

Date: 4 June 2014 **Language:** English **Number of pages:** 64 + 5

Degree: Master of Science in Business Administration

Supervisor: Esko Penttinen

Objective of the study

The objective of this thesis is to examine the components of information system quality and to develop a model for evaluating the impact of good quality on business value created by information systems (IS). The study aims to create a practical instrument that can be used to define metrics for quality in information systems, to improve the communication between the different stakeholders of information systems, and – eventually – to assure and increase the value of information systems.

Theory and methodology

The existing literature did not provide any single framework through which the phenomenon could have been explored. Therefore, a theoretical framework was developed through a thorough investigation on IS quality, IS business value, and IS measurement systems. Based on the investigation, the study introduces a business value approach to IS quality. Constructive research was used as a research method, and semi-structured interviews were conducted to gather new real-world data to the research.

Findings and conclusions

The findings consolidate previous research on IS quality and IS measurement systems. The research indicates that good quality is a precondition for reaching the intended IS business value. Increasing dependence on information systems and the huge costs of poor quality software draw management's attention towards software quality improvement. However, no management process exists that would ensure the realization of good quality. The study proposes a conceptual model that can be used as a tool for evaluating the business value of good quality in information systems.

Keywords: information system, quality, process, performance measurement, business value

Tekijä: Eero Talonen

Työn nimi: Hyvän laadun liiketoiminta-arvo tietojärjestelmissä

Päivämäärä: 4.6.2014 **Kieli:** Englanti **Sivumäärä:** 64 + 5

Tutkinto: Kauppatieteiden maisteri

Työn ohjaaja(t): Esko Penttinen

Tutkimuksen tavoitteet

Tämän tutkimuksen tavoite on tarkastella tietojärjestelmän laadun osatekijöitä ja kehittää malli, jonka avulla voi arvioida hyvän laadun vaikutusta tietojärjestelmien tuottamaan liiketoiminta-arvoon. Tutkielmassa pyritään luomaan väline, jonka avulla voidaan käytännössä määrittää mittarit tietojärjestelmän laadulle, parantaa kommunikaatiota tietojärjestelmien eri sidosryhmien välillä ja lopulta varmistaa ja kasvattaa tietojärjestelmien arvoa.

Teoria ja tutkimusmenetelmät

Aiemmasta aihetta käsittelevästä kirjallisuudesta ei löytynyt yksittäistä viitekehystä kattamaan ilmiötä. Näin ollen, tutkielmassa kehitettiin teoreettinen viitekehys kattavan tutkimuksen pohjalta. Tutkimuksen tuloksena on syntynyt uusi liiketoiminta-arvon näkökulma tietojärjestelmien laatuun. Tutkimusmenetelmänä toimi konstruktiivinen tutkimus, ja uutta dataa kerättiin avoimilla haastatteluilla.

Tutkimuksen tulokset ja johtopäätökset

Tutkimuksen tulokset yhdistävät aiempaa tutkimusta tietojärjestelmien laadusta ja mittaamisesta uudeksi kokonaisuudeksi. Tutkimus osoittaa, että hyvä laatu on edellytys tavoitellulle tietojärjestelmien liiketoiminta-arvolle. Kasvava riippuvuus tietojärjestelmistä ja huonon laadun suuret kustannukset ovat johtaneet siihen, että myös yritysjohto on yhä kiinnostuneempi laadun parantamisesta. Hyväksi todettua johtamisprosessia, jolla varmistetaan hyvä laatu, ei kuitenkaan ole olemassa. Tutkimus esittää käsitteellisen mallin, jota voi käyttää työkaluna hyvän laadun liiketoiminta-arvon arvioimiseen.

Avainsanat: tietojärjestelmä, laatu, prosessi, suorituskyvyn mittaaminen, liiketoiminta-arvo

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ABBREVIATIONS

BPI	Business Process Improvement
BPR	Business Process Re-engineering
BSC	Balanced Scorecard
CEO	Chief Executive Officer
CIO	Chief Information Officer
ERP	Enterprise Resource Planning
IM	Information Management
IS	Information Systems
ISO	International Organization for Standardization
IT	Information Technology
ITIL	Information Technology Infrastructure Library
KPI	Key Performance Indicator
QA	Quality Assurance
SQA	Software Quality Assurance
TQM	Total Quality Management

1. INTRODUCTION

"Price is what you pay. Value is what you get."
– Warren Buffett

Executives are increasingly aware that information systems (IS) have a direct impact on business performance. Information systems today have the potential to enhance productivity, improve profitability, reduce cost, and reduce inventory, among others. Beyond these economic benefits, IS can affect organizations by creating results that are not directly measurable in monetary terms, such as, competitive advantage, employee satisfaction, customer retention, or societal value. Indeed, information systems today are enabling corporate strategy and they often have the ability to affect both the internal and the external stakeholders of the business (Hallikainen et al. 2002; Hallikainen 2003).

The term IS business value – a core construct of this study – is commonly used to describe this impact. As defined by Melville et al. (2004, p.287), this study considers IS business value as the organizational performance impacts of information systems at both the intermediate process level and the organization wide level, and comprising both efficiency impacts and competitive impacts.

While investments in IS are growing they rarely return the intended return on investment. Many of the projects still fail or at least exceed their budgets. On the other hand, projects can appear successful, and still not create the intended business value. In fact, at the end of the 21st century, more than two-thirds of Fortune 100 companies' chief executive officers believed that their firms were not getting the most of their IT investments (Anandarajan & Wen 1999). Ten years later, an extensive survey by the Standish Group (2009) still corroborates this, concluding that three-quarters of IT-enabled investments do not deliver their expected value.

This observation raises a question of whether or not managers know how to effectively measure the return on investment from information systems. Moreover, it highlights the importance of quality assurance in information systems as effective quality assurance can ensure good quality and consequently influence the realization of the expected business value. Indeed, as software becomes more and more pervasive, there has been a growing concern in the information technology industry about software quality (Sudhaman 2011).

The increasing dependence on information systems and the huge costs of poor quality software drive management attention towards software quality improvement. "The cost of faulty software in the US runs into tens of billions of dollars and it represents approximately 1% of Gross Domestic Product"

(Gorla & Lin 2010). Despite the concern on quality, many executives and even some quality personnel tend to regard software quality as an expense. They also relate quality with longer schedules and raised development costs even though empirical research shows the opposite to be true (Jones & Bonsignour 2011, p.xxii).

What is more, software quality assurance and software quality costs have not received as much attention from the research community as other economic aspects of software development. Over the last three decades, a number of articles on this topic have appeared in a range of journals, but comprehensive overviews of this body of research are not available (Karg et al. 2011).

Furthermore, it appears that there is no consensus on how to define quality. According to Reeves and Bednar (1994, p.1), quality has been variously defined as value, conformance to specifications, conformance to requirements, fitness for use, loss avoidance, and/or exceeding customers' expectations. Regardless of the time period or context in which quality is examined, the concept has had multiple and often muddled definitions. This is a fundamental problem when estimating the value and benefits that stem from quality.

> *"As we discuss, the literature linking quality to outcomes such as market share, cost, and profits has yielded conflicting results that are largely attributable to definitional difficulties. Increased understanding of these important relationships will occur only when the quality construct is more precisely defined."*
>
> – Reeves & Bednar *(1994, p.420)*

1.1. The business value of good quality in IS

Traditionally, the value of quality in IS has been evaluated by measuring failure costs such as anomalies in the quality of service that result in software rework or corrective maintenance. That is, the cost of bad/missing quality that oftentimes turns up late in the IS lifecycle. This has also allowed for the measuring of return on investment in monetary terms: the value of good quality could simply be defined as money saved in failure costs benchmarked against other companies with lower or higher investments in quality assurance.

That being said, it seems that in light of the literature reviewed so far, there is no consensus on how to accurately perform this evaluation as research on IS quality costs is rather fragmented. While some economic aspects, such as software development effort estimation and software process improvement have frequently been discussed, others have received less attention. Indeed, little research has specifically been devoted to those costs which are "incurred in the pursuit of

[software] quality or in performing quality-related activities" (Pressman 2010, p.407). This is remarkable, because software vendors typically spend 30–50% of their development budget on defect detection and correction (Ebert and Dumke (2010) cited in Karg et al. 2011, p.415).

Moreover, it can be claimed that *good* quality essentially means creating the intended business value that is not reduced by missing quality. In other words, good quality leads to success. Therefore, it appears that good quality in IS will result in a higher return on investment than what is simply the cost of bad quality. For instance, good quality software, due to quality planning and training (part of the so called prevention costs), needs less maintenance in the future, thus, saving time, and creating positive synergy effects. However, as Karg et al. (2011) point out, prevention costs, which help to avoid future appraisal and failure costs, have gained the least attention in software quality cost research, in spite of their big cost impact.

1.2. Research problem and objectives

Being able to measure the business value of good quality in practice would serve the ICT industry in many respects. As the topic is still rather elusive, to both the industry and the research community, concrete research is needed to understand the issues at hand. Consequently, this study intends to investigate if good quality in IS can create positive business value.

The main research question is stated as follows:

How can one evaluate the business value of good quality in information systems, during the life-cycle of the investment?

In order to answer the research question the following research objectives are presented:

O1. Review the academic literature for previous concepts, theories, models, methods, and empirical results, consolidate perceptions of quality and its relation to IS business value.

O2. Find out how companies currently measure their investments in IS, and how this relates to their perception of quality.

O3. Construct a model for evaluating the business value of good quality in IS. Ideally, this model should be generic enough to be applicable in many different cases.

1.3. Scope of the study

Quality is a broad concept that can be approached in a number of ways. A leading thought throughout the study is that *good quality* in information systems positively correlates with the success of a system, during its whole life-cycle. This study discusses different aspects of quality, and ultimately takes a restricted approach to it; namely, a business value approach to information system quality. That is, *quality refers to the ability of the information system to create the intended business value*. Moreover, for the purposes of this study, *success* is considered a state where an information system creates the intended business value.

It is useful to discuss the term *value* that is ambiguous in both daily use and literature. As Jones & Bonsignour (2011, p.435) point out, there are many kinds of value in addition to economic value. For example, medical software that aids physicians in diagnosing illness has enormous value for health care, even though it's not exactly *economic* value. Software that improves national security or military effectiveness is also extremely valuable, but this kind of value is in addition to its economic value. In this study, value is discussed in conjunction with IS business value (defined in chapter 1) and, thus, encompasses all forms of value that determine the health and well-being of the organization in the long run.

Now, it is also postulated that the intended value naturally derives from business objectives since information systems ultimately exist to support business objectives. It is important to note, however, that actually realizing the value requires more than just meeting the business objectives. For instance, a system that is built on time and budget, meets the technical requirements, and supports the pre-defined business objectives, can appear successful but is, in fact, of poor quality unless it is also accepted by the end-users. This type of an "Illusion of Success" is illustrated in Figure 1.

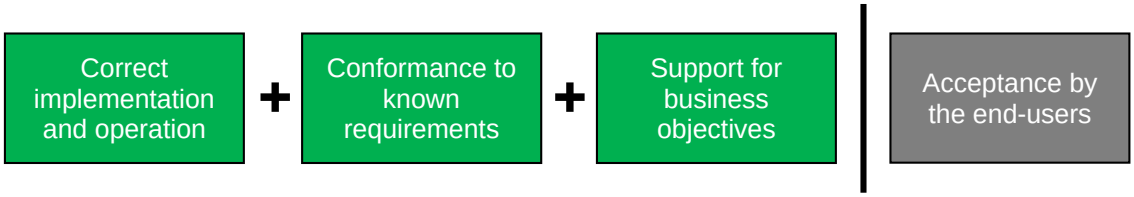

Figure 1: Illusion of Success, no acceptance (modified from Hannula, 2011)

In this study, the business value of good quality in information systems is examined only from the point of view of the entity that makes the financial investment in the system. This is an important remark as concepts such as quality and success are always unique to the stakeholder's

point of view. For instance, a customer might deem a system that is easy to use successful even if the same system completely failed to meet its business objectives.

Software Quality Assurance (SQA) refers to the planned and systematic activities that ensure the quality of a software product or service. It involves systematic measurement, comparison with a standard, monitoring of processes and methods, and an associated feedback loop that promotes error prevention.

Quality Management (QM) is defined as an integrated approach to achieving and sustaining high quality output, focusing on the maintenance and continuous improvement of processes and defect prevention at all levels and in all functions of the organization, in order to meet or exceed customer expectations (Flynn et al. 1994, p.342).

1.4. Structure of research

The Master's thesis began with an *Introduction* that summarized the reasons behind the research, the key research objectives, and the scope of the study. The second chapter presents the *Literature review* in which existing academic and professional literature are examined in regard to the main research question and research objectives. The aim of the literature review is to prepare for the theoretical framework that attempts to structure the content of the literature review and guide the following discourse in relation to the literature review. The following chapter, *Research Methodology*, will then conclude the structure of the thesis and discuss how the data will be further analyzed and developed. The empirical part of the study is presented in the next chapter, *Evaluating Investments & Quality in Case Companies*. This chapter introduces new real-world data to the research that is then discussed and analyzed in the next chapter, *Evaluating the Business Value of Good Quality*. Here, the literature and empirical data will be used as a means to an end – to draw conclusions in regard to the Research Question and, in particular, Research Objective 3. The final chapter, *Conclusions*, sums up the research work and provides the reader with a synopsis of the research results. In other words, it answers the Research Question and discusses all of the Research Objectives, and how they were met.

1.5. Qentinel Ltd

This study is done as an assignment to Qentinel Ltd. Qentinel is a privately owned Finnish company specializing in the quality assurance of IT systems. Essentially, the company strives to ensure the success of its customers' investments in IT. Qentinel's customers are companies and

public organizations from different industrial sectors, such as health, finance, information and communications technology, and government. The company employed approximately 100 people and had an annual turnover of approx. 10 million Euros in 2013.

Qentinel offers a comprehensive range of services that cover the entire lifecycle of IT systems – from business needs to production. Services include, among others: project management for a successful acquisition (including planning, tendering, and implementation), testing, quality management, service development such as process and strategy development, service monitoring, service level management, and auditing. In other words, Qentinel's business consists of consultancy services and other highly knowledge intensive services.

An essential challenge that the company faces is how quality and business benefits can be defined and measured in practice. Qentinel has done research on how quality is created in information systems for several years now. The research that is still in progress has resulted in a concept called "the Quality Scale" where quality is closely related to the success of an IT project. However, the concept is still rather theoretical, and in need of a more practical side and implementation.

The nature of Qentinel's business has been considered in the execution of this study. Ideally, the research will create significant benefits for both Qentinel and its customers by influencing the justification of investments in quality.

2. LITERATURE REVIEW

This purpose of this chapter is to review existing academic and professional literature in order to consolidate perceptions of quality and its relation to IS business value. Moreover, research on measuring investments will be discussed. As a result, a theoretical framework will be developed for the analytical part of the study. Emphasis is on research that already has some empirical findings. The literature includes but is not limited to various concepts, definitions, theories, models, methods, tools, and frameworks surrounding the topic of the study.

2.1. The dimensions of good quality in IS

"High-quality software is not expensive. High-quality software is faster and cheaper to build and maintain than low-quality software, from initial development all the way through total cost of ownership."

– Capers Jones (2011)

As described in the Introduction, there is an increasing interest in good quality in information systems. However, there is no real consensus on how to define quality in the first place. This section addresses the broad concept of quality in an attempt to consolidate previous research, in particular, in relation to IS.

A set of determinants of what constitutes a good set of quality dimensions is followed in identifying the components of good quality in IS, in accordance with research by Nelson et al. (2005, p.202) and Jones & Bonsignour (2011, p.10). The components of good quality should:

- be *complete* (in the sense of explaining overall IS quality);
- be relatively *parsimonious*;
- *enhance understanding* of the multifaceted nature of information system quality;
- be *predictable* before projects start;
- be *measurable* during and after projects are finished; and
- be *actionable*, in the sense that the dimensions can be influenced through system design or managerial intervention.

2.1.1. Quality defined

"The first step in developing a measurement instrument is to articulate the theory and concepts which underlie it, providing a foundation for content validity, or the extent to which an instrument measures relevant concepts."
– Flynn et al. (1994, p.342)

It is important for both researchers and practitioners to understand the nature of quality. In fact, as Buzzell & Gale (1987) cited in Reeves & Bednar (1994, p.440) point out: "in the long run, the most important single factor affecting a business unit's performance is the quality of its products and services, relative to those of competitors".

Quality can be interpreted in a number of ways. Joseph M. Juran's Quality Control Handbook, an edited volume of quality control methods, begun in 1945, and is now one of the most cited volumes concerning quality. Juran points out that there have been efforts to clarify matters by adding supplemental words, such as *positive* quality and *negative* quality. However, some confusion is inevitable as long as we use a single word to convey different meanings. To date, none of the clarifications have gained a broad acceptance. (Juran 1999, p.2.2)

Initially, Juran separated quality into two components: *quality of design* and *quality of conformance*. In 1988, in the fourth edition of the book, he defined quality as *fitness for use*. The latest edition, in turn, recognizes the change from managing quality in a traditional manufacturing industry to the management of quality in general (Juran 1999). Consequently, quality is defined as follows:

1. *"Quality" means those features of products which meet customer needs and thereby provide customer satisfaction. In this sense, the meaning of quality is oriented to income. The purpose of such higher quality is to provide greater customer satisfaction and, one hopes, to increase income. However, providing more and/or better quality features usually requires an investment and hence usually involves increases in costs. Higher quality in this sense usually "costs more."*

2. *"Quality" means freedom from deficiencies—freedom from errors that require doing work over again (rework) or that result in field failures, customer dissatisfaction, customer claims, and so on. In this sense, the meaning of quality is oriented to costs, and higher quality usually "costs less."*

   – (Juran 1999, pp.2.1–2.2)

In other words, Juran suggests that, in managing quality, the two most important meanings to consider are *meeting customer needs in order to increase income* and *the freedom of deficiencies*. Figure 2 illustrates this in more detail.

Product features that meet customer needs	**Freedom from deficiencies**
Higher quality enables companies to:	Higher quality enables companies to:
Increase customer satisfaction Make products salable Meet competition Increase market share Provide sales income Secure premium prices	Reduce error rates Reduce rework, waste Reduce field failures, warranty charges Reduce customer dissatisfaction Reduce inspection, test Shorten time to put new products on the market Increase yields, capacity Improve delivery performance
The major effect is on sales.	Major effect is on costs.
Usually, higher quality costs more.	Usually, higher quality costs less.

Figure 2: The meanings of quality (Juran, 1999)

Reeves & Bednar (1994) attempt to clarify the concept of quality by tracing the evolution of quality definitions in a comprehensive review of literature. Their study presents four different definitions for quality that are discussed further: quality is excellence, quality is value, quality is conformance to specifications, and quality is meeting and/or exceeding customers' expectations.

Quality is excellence stems all the way from ancient Greek where philosophers such as Socrates, Plato, and Aristotle discussed the notion. More recently, Tuchman (1980) argued that quality is about achieving the highest standard as against to being satisfied with something less. It does not allow compromises.

Quality is value originates from the mid-1700s according to Reeves & Bednar. During that time, defining quality as excellence was not appropriate anymore in commercial context. As

businesses began to produce cheaper inferior goods, quality was judged by price. In other words, the standards of excellence need to be assessed relative to the cost of achieving them.

Quality is conformance to specifications is based on advancements in the manufacturing and technology industries. That is, mass production that would never have been possible without strict standards on quality. According to Reeves & Bednar, the first and one of the most influential works on quality was the 1931 publication of Shewhart's *Economic Control of Quality of Manufactured Product*. Shewhart's work later led to statistical quality control as a means to ensure quality. Other authors have discussed this definition further. For instance, Crosby (1979) considered quality as "conformance to requirements". The bottom line is that quality be assessed in terms of delivering value relative to a specific design.

Quality is meeting and/or exceeding customers' expectations defines quality in the most pervasive way. Reeves & Bednar observe that the definition falls back to services marketing literature, wherein researchers argued that a conformance-to-specifications definition of quality failed to address the unique characteristics of services. This definition of quality that was based on consumer perception gained momentum as the Western world started to move toward service-based economies. The evolution of the new approach to quality can also be seen in the publications by the most prominent researchers of the field. For instance, the Quality Control Handbook by Joseph M. Juran introduced a widely used definition of quality, "fitness for use", in 1974. However, in a later edition of the same publication, the definition was extended with "meeting customer needs" and "freedom from deficiencies".

Reeves & Bednar conclude that multiple definitions and models of quality are necessary to capture the complexity and richness of the concept. Different definitions of quality are appropriate in different circumstances, and thus, a global definition does not exist. Consequently, the challenge is rather to develop models and definitions that are comparable, and that account for many of the components of quality. Furthermore, the authors argue that choosing the appropriate definition of quality is of utmost importance in developing measurement methods and conceptual frameworks that involve quality.

2.1.2. Quality in information systems

''Software quality can determine the success or failure of a software product in today's competitive market."
– Jeff Tian (2004)

Let us go back to the study's definition of quality: *quality refers to the ability of the information system to create the intended business value*. Now, this ability of a given information system naturally depends on a multitude of factors. In this sub-section, existing research on quality in information systems is being investigated in order to identify the factors that affect quality in IS. According to several authors, research in this area is at best fragmented with focus only on subsets of IS quality (Gorla & Lin 2010; Issac & Anantharaman 2004; Jones & Bonsignour 2011; Nelson et al. 2005; Stylianou & Kumar 2000; Sudhaman 2011).

Gorla & Lin (2010) state that management is shifting attention towards software quality improvement because of an increasing dependence on information systems and the huge costs of poor quality software. Despite this, software quality today is no better than decades ago and is worse in some cases. Furthermore, there have been only few comprehensive studies on factors that influence software quality, and that would consider user and organizational influence in addition to technical characteristics.

Indeed, the discourse on quality in information systems is often centered around the technical characteristics of a system. Consequently, one might define quality assurance simply as testing (Chappell 2012a). However, as Chappell points out, achieving real software quality requires a much broader view. He claims that assuring quality means focusing on every aspect of application lifecycle management. That is, creating high quality software requires efforts in development (the process of creating an application) and operations (running and managing the application after it's deployed) as well as in governance (decisions made about the application during its lifetime such as creating the business case or project management during development). In other words, "quality can't be tested in; it must be built in throughout a project".

Similarly, Jones & Bonsignour (2011) remark that software quality cannot be equated with testing or quality assurance. Software, by its very nature is subject to unknown unknowns and no amount of functional or nonfunctional testing can be designed to detect and correct these

problems. According the authors, quality in software can be categorized into seven major focus areas: 1) *Technical or structural quality*, including reliability, defects, and defect repairs; 2) *Process quality*, including development methods that improve quality; 3) *Usage quality*, including ease of use and ease of learning; 4) *Service quality*, including access to support personnel; 5) *Aesthetic quality*, including user satisfaction and subjective topics; 6) *Standards quality*, including factors from various international standards; and 7) *Legal quality*, which includes claims made in lawsuits for poor quality.

Furthermore, the authors present a list of 121 quality attributes that can be used in evaluating quality. Derived from this list the authors propose the 12 most significant factors that together should lead to high quality in software:

Table 1 The 12 Most Effective Software Quality Factors

1. Low defect potentials
2. Effective defect prevention methods
3. High defect detection efficiency (DDE)
4. High defect removal efficiency (DRE)
5. Use of pretest inspections
6. Use of pretest static analysis
7. Use of formal test case design
8. Good ease of learning
9. Good ease of use
10. Good technical support
11. High user satisfaction
12. Good warranty

Prahalad and Krishnan (1999) discuss quality in the information age and argue that a new view of quality is needed in order to assess organizations' IT infrastructure. The authors state that in information systems, unlike in manufacturing, the concept of quality usually

incorporates both the conformance and service views of quality. Indeed, while in manufacturing, the primary goal of quality assurance is to minimize defects in products created through a repeatable process, in software, development generally requires some innovation and cannot be considered a repeatable process. Thus, views on quality rooted in manufacturing are not comprehensive and a broader perspective on quality is required (Chappell 2012b).

Moreover, Prahalad and Krishnan (1999) remark that in IS, the system is expected to be reliable and meet its specifications while it should also consider the needs of a heterogeneous customer base. Furthermore, these needs change continuously which leads to new quality expectations that managers must take into account. Consequently, the authors propose a synthesis of conformance, adaptability, and innovation that constitute a new perspective of quality in information systems.

Juran (1999, sec.2.2) also emphasizes the move from conformance with specifications to meeting customer needs. He states that while – for a long time – quality departments defined quality as *conformance to specification* they assumed this would also meet customer needs. However, this assumption was logical only since these departments seldom had direct contact with customers. That is, customer needs can include many things not found in product specifications, such as: confidentiality, freedom from burdensome paperwork, and clear instructions. As a result, quality departments need now to revise their definition of quality to include customer needs that are not a part of the product specification.

Gorla & Lin (2010) assert that software quality is an important success factor in all information systems. Similarly, DeLone & McLean (1992) consider quality, namely information and system quality, and later in research also service quality (ibid, 2003), as the key initial determinants for IS success. These models along with other research on measuring IS quality and success are further investigated in section 2.4.

In fact, there have been many efforts in past research to explain the relationship between quality in IS and success in IS. However, researchers often define quality in IS and its dimensions differently or at least by different taxonomies. Consequently, further research becomes more difficult. On the other hand, as Gorla & Lin (2010, p.608) state:

"Software quality should be defined based on the context and not all quality attributes are important in all contexts"

The authors explain that software quality can be defined by two types of product characteristics: (i) external quality (how the product works in its environment), such as, usability and reliability, and (ii) internal quality (how the product was developed), such as, software structure, complexity, and size. Similarly, Neely et al. (2005) discuss these characteristics in the context of performance measurement. They relate effectiveness and efficiency to external and internal quality, respectively. For instance, measuring a quality-related attribute of performance such as product reliability can be quantified by using effectiveness and efficiency. Achieving a higher level of reliability might lead to greater customer satisfaction (effectiveness) while also reducing failure costs (efficiency).

Gorla & Lin (2010) observe that in the case of external quality, quality in IS can be described by five different attribute that are based on the ISO/IEC 9126 quality model: system reliability, maintainability, ease of use, usefulness, and relevance. ISO/IEC 9126 is a set of software product quality standards published by the Joint Technical Committee 1 of the International Organization for Standardization and International Electrotechnical Commission.

In the standard, software quality is defined as ‘‘the totality of features and characteristics of a product or service that bears on its ability to satisfy given needs” (ISO/IEC 9126 2001). In other words, its main purpose is the representation of quality of software as seen by software users (Bazzana et al. 1993, p.80). ISO/IEC 9126 defines a quality model that comprises six characteristics and 27 sub-characteristics of software product quality. This generic quality model can be applied to any software product by tailoring it to a specific purpose (Jung et al. 2004). Figure 3 describes the model in further detail.

Characteristic	Subcharacteristics
Functionality	Suitability, accuracy, interoperability, security, functionality compliance*
Reliability	Maturity,* fault tolerance,* recoverability,* reliability compliance*
Usability	Understandability, learnability, operability, attractiveness, usability compliance*
Efficiency	Time behavior, resource utilization, efficiency compliance*
Maintainability	Analyzability, changeability, stability, testability, maintainability compliance*
Portability	Adaptability, installability, replaceability, coexistence, portability compliance*

Figure 3: Characteristics and sub characteristics in ISO/IEC 9126 (Jung et al. 2004, p.89)

Also Nelson et al. (2005) observe the attributes and antecedents driving information and system quality. They argue that researchers have focused too much on the perceptions related to IT use, in particular, ease of use and usefulness of information technology. Often, quality as a key dependent variable has been largely supplanted by usage in the IS literature. In an effort to better describe all of the factors affecting IS quality and, thus, the business value created by IS, the authors present a model consisting of nine fundamental determinants of quality in IS.

The model is similar to Gorla & Lin's (2010) research in that it separates IS quality into to two categories: information quality and system quality. Information quality is related mainly to the output of an IS whereas system quality reflects the information processing system required to produce that output. The key dimensions of information quality are accuracy, completeness, currency, and format. The key determinants of system quality are accessibility, reliability, response time, flexibility, and integration. The model is further investigated in section 2.4.

As mentioned before, quality is a complex issue and even more so in information systems. Stylianou & Kumar (2000) emphasize multiple stakeholder groups and product, service, and process quality in managing IS quality. They introduce "a philosophy of total IS quality", a multidimensional concept that describes quality in IS. Other authors have, as well, concluded that IS quality constructs are multidimensional (Dahlberg & Jarvinen 1997; Flynn et al. 1994; Guimaraes et al. 2009; Nelson et al. 2005). Figure 4 explains the philosophy further.

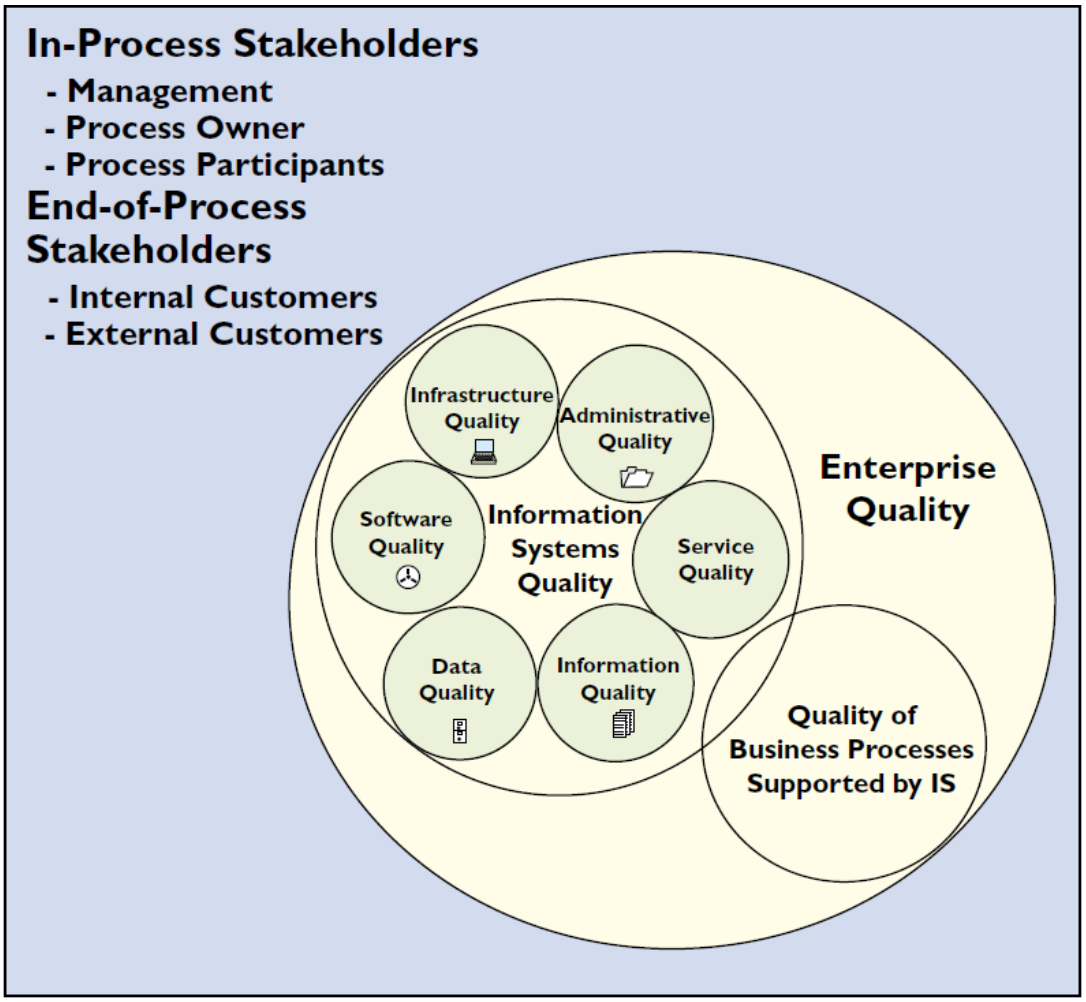

Figure 4: Dimensions of IS quality (Stylianou & Kumar 2000, p. 100)

The dimensions overlap considerably with each other, and affect each other. *Infrastructure Quality* includes the hardware and enabling software that is maintained by IS, for example, the quality of networks. *Software Quality* includes the applications software that is built, maintained, or supported by IS. *Data Quality* includes the data entering the various information systems. *Information Quality* includes the output resulting from the information systems. *Administrative Quality* includes the management of the IS function, such as, the quality of budgeting, planning, and scheduling. *Service Quality* includes the service component of the IS function, that is, the quality of customer support processes such as those related to a help desk. Moreover, it appears that this service component is not given the appropriate consideration in systems development despite its big impact, in particular, in managing IS costs.

In addition, the quality of the related business processes has an impact on the total quality in IS. In fact, IS products and services are often part of a larger business process that is not owned

by IS. This is a synergetic relationship: a well-designed business process will benefit from good quality in IS and vice versa. Stylianou & Kumar argue that in order to achieve good quality in IS, organizations need to identify the key business processes and, for each process, the important stakeholders and quality attributes. Furthermore, IS management should be involved in the design of these business processes in the first place, thus, ensuring good quality standards for the business as well as the IS.

What is more, understanding different stakeholders in information systems is a key issue to understanding quality in the context of IS. For any one system there are always various perceptions of quality (Jones & Bonsignour 2011, p.1; Stylianou & Kumar 2000). Stylianou & Kumar (2000, p.101) call this the "voice of multiple stakeholders". IS stakeholders include individuals or groups concerned with the production, delivery, management, and support of IS products and services, as well as the end-users who are the "end-of-process stakeholders", either internal or external to the organization.

According to Stylianou & Kumar, the emphasis has long been on satisfying the internal end-users. However, IT can now be used to gain competitive edge and to add value to products and services. As a result, embedded systems are becoming more common and external users' opinion becomes a part of IS quality.

Moreover, Keen (2011, p.16) points out that the notion of value is an elusive, highly personal moving target. Value means different things to different people and even to the same people at different times. Jones & Bonsignour (2011, p.1) explain that, for instance, for a software vendor, revenue is the key element of value whereas for a consumer, operational factors represent primary value. To conclude, in order to successfully design and implement an IT-enabled solution, steps must be taken to ensure that all stakeholders are marching toward the same value (quality) goal.

2.1.3. Quality Scale

As described in the introduction, Qentinel has done extensive academic and professional research on how quality and value is created in information systems. As part of its strategy change, the company has built a quality model called the Quality Scale. The model can be used to illustrate different dimensions of IS quality and to map value propositions and service offerings for these different quality aspects (Hannula & Töhönen 2011).

Quality Scale attempts to describe the business value of quality in IS in practice through four dimensions of quality. According to the company, the value of quality should be (ultimately) presented in terms of business goals and preferably as much in monetary terms as possible. Thus, in addition to defining quality, the model aims to improve the measurement of quality in IS. Furthermore, instead of valuing quality through the costs of missing quality (i.e. negative valuing), it is intended that the value of quality should also be measured through the added value it provides (i.e. positive valuing). The model is illustrated in Figure 5.

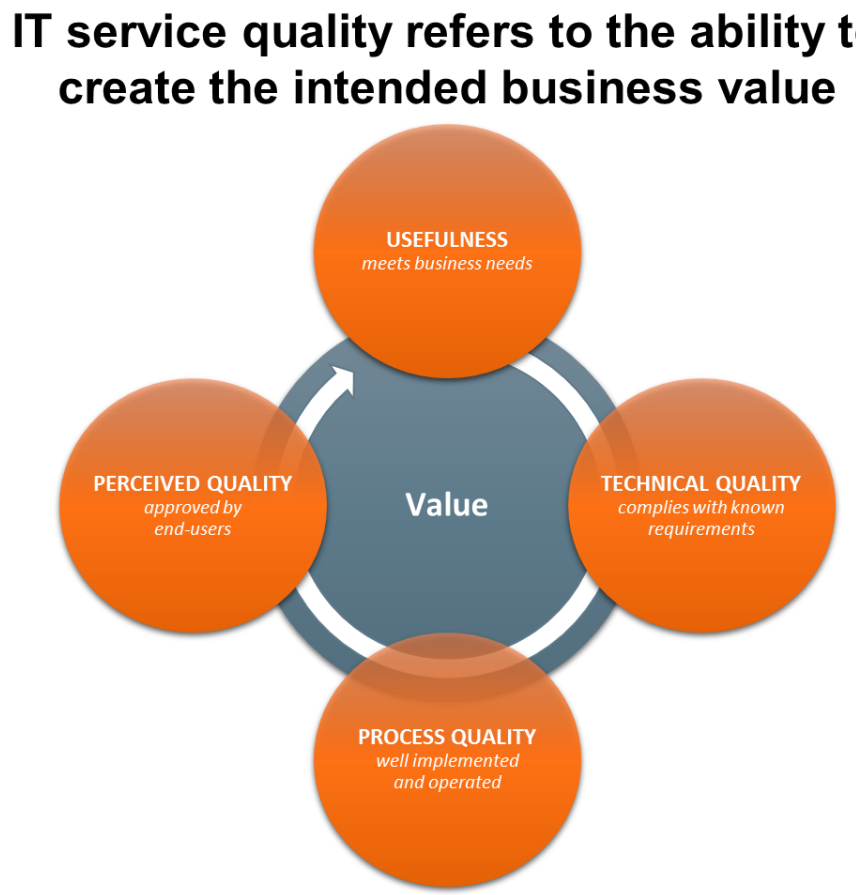

Figure 5: Qentinel Quality Scale

In Quality Scale, good quality is seen as a proxy measure for the potential value of successful IS through its lifetime. This integrated view also recognizes the fact that quality in information systems is a complex issue and judged differently by different stakeholders. Moreover, the model emphasizes that quality is actually created by the actions before the system is in use. That is, processes such as planning, coding, testing, and implementation all affect the final perception of quality that is hard to change afterwards (i.e. after implementation).

It is also important to note that even though the Quality Scale is strongly influenced by Qentinel's past academic research, this particular model and its dimensions do not have detailed academic descriptions. That is, the model is a combination of academic knowledge and in-depth experience by software quality assurance professionals.

The information system is deemed of high quality only when all of the dimensions in the model are of high quality. *Technical quality* refers to the technical requirements that a system might have, such as, response time, maximum number of bugs, and performance. *Process quality* emphasizes the importance of the processes in both the development and operation of the system, such as, project management that follows budget and schedules, methods in testing, and transparency in the process-flow. *Perceived quality* is high when the information system is accepted by the end-users. In other words, this dimension includes factors such as ease of use, amount of users, and overall user satisfaction. *Usefulness* emphasizes that an information system is always created based on business needs. Even though this can appear quite self-evident, there have been countless cases where all the other dimensions achieved high quality but the system did not meet the intended business goals and/or did not work in accordance with business methods. Examples of factors under usefulness include increase in productivity, new services, and reduced costs.

In addition, Hannula (2011) remarks that there are two types of quality assurance: dynamic and declaratory. Dynamic QA produces *quality intelligence* that can affect decision-making in time and that considers all stakeholders. Declaratory QA, on the other hand, creates information about quality too late, and cannot, thus, affect decisions.

Dynamic quality assurance is based on accurate measured information that reflects the relevant quality criteria of a given information system at a point in time. Thus, it is possible to predict the outcomes of different decisions, and ensure that quality criteria is met – or even improved. Moreover, the quality criteria in dynamic QA should always reflect all of Quality Scale's dimensions. Thus, the relevant information of quality should also describe quality's influence on, for instance, business turnover, profitability, and level of risk.

2.2. Measurement systems in evaluating investments

"Anything you need to quantify can be measured in some way that is superior to not measuring it at all."

– "Gilb's law", van Solingen (2006, p.27)

This section reviews literature on measurement systems. In business, these systems are used, in effect, to evaluate the (tangible or intangible) value of an investment. Understanding the general principles of measurement systems is paramount in creating a new model of evaluating IS quality.

2.2.1. Performance measurement

Neely et al. (2005) discuss the importance of performance measurement in an article originally published in 1995. They define performance measurement as "the process of quantifying action, where measurement is the process of quantification and action leads to performance" (p.1228).

The authors relate performance to two concepts in particular, *effectiveness* and *efficiency*. Effectiveness refers to the extent to which customer requirements are met while efficiency is a measure of how well the firm's resources are utilized in order to reach a given level of customer satisfaction. In other words, there can be internal (efficiency) as well as external (effectiveness) reasons to take a course of action to achieve the intended performance. Achieving high effectiveness and efficiency would, in effect, imply good performance as well as competitive edge. Thus, a *performance measure* is defined as a metric used to quantify the efficiency and/or effectives of an action.

According to Neely et al. a performance measurement system is defined as the set of metrics used to quantify both the efficiency and effectiveness of actions. A metric is "a quantitative measure of the degree to which a system, component, or process possesses a given attribute" (IEEE Std 610.12 1990). In other words, a measure alone provides little meaningful information unless it is compared with another measure, and when it is compared, it becomes a metric (Nygård 2011).

All performance measurement systems consist of a number of individual performance measures. These measures can be categorized in various ways, ranging from Kaplan and Norton's balanced scorecard through to Fitzgerald et al.'s framework of results and determinants (Neely et al. 2005, p.1231). Some of these methods will be examined further in the following sub-sections.

A performance measurement system can be examined at three different levels: (1) the individual performance measures; (2) the performance measurement system as an entity; and (3) the relationship between the performance measurement system and the environment within

which it operates. This framework for performance measurement system design is depicted in Figure 6.

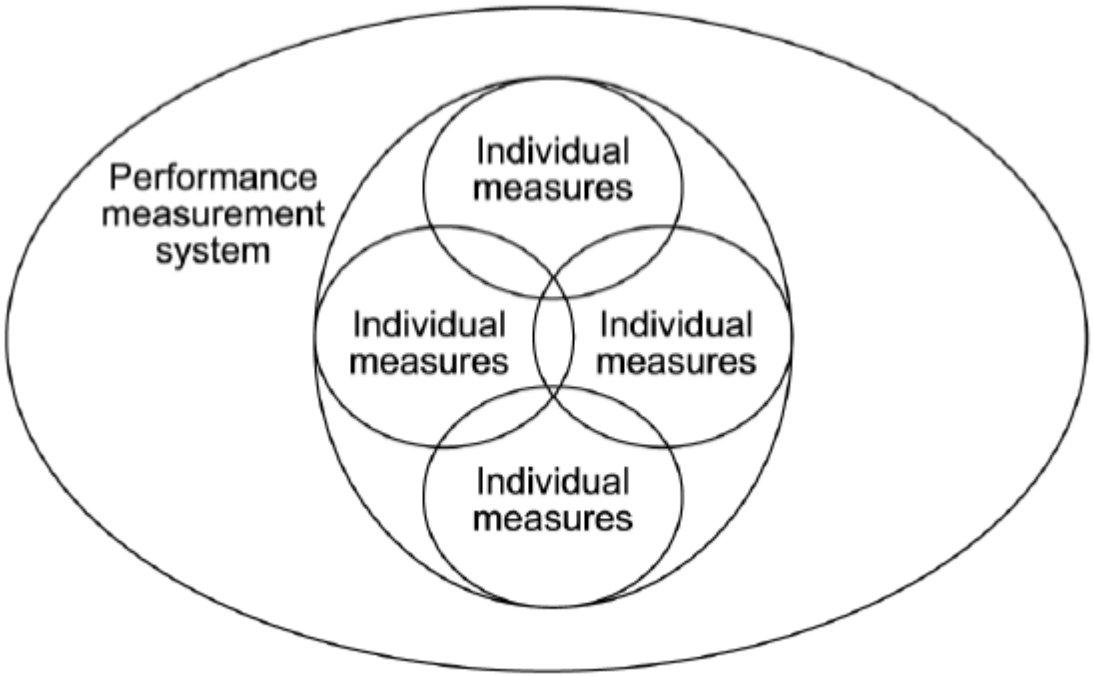

Figure 6: A framework for performance measurement system design (Neely et al. 2005)

2.2.2. Balanced Scorecard

The Balanced Scorecard (BSC) is a management tool developed by Kaplan & Norton. The balanced scorecard enables a strategy to be broken down into key performance indicators. Performance against the KPIs is used to demonstrate how well the strategy is being achieved.

The BSC is designed to be a framework that translates a company's strategic objectives into a set of performance measures, including both financial and non-financial metrics (Kaplan & Norton 1996). The original authors' research in 2004 claims that more than 75% of an average firm's market value is obtained from its intangible assets (Kaplan & Norton 2004).

The BSC has four major domains, or areas, or perspectives, each of which has a small number of KPIs. The same four domains are considered at different levels of detail throughout the organization. An organization defines goals for each of the domains and, thus, is able to monitor the performance of the whole organization. The four domains are:

1. *Customer perspective*: How do customers see us? Encourages the identification of measures that describe how customer value is created. Examples: percent of sales from new products, on time delivery.

2. *Internal perspective*: What must we excel at? Measures on the internal processes that transform assets into customer value and financial performance. Examples: cycle time, unit cost.

3. *Innovation and learning perspective*: How can we continue to improve, create value and innovate? Often measures that concern intangible assets. Examples: time to develop new generation of products, life cycle to product maturity.

4. *Financial perspective*: How do we look to shareholders? Relevant high-level financial measures. Examples: cash flow, return on equity.

The BSC has also been used in the context of IT measurement. For instance, in the Information Technology Infrastructure Library (Cabinet Office 2011) the BSC is used as illustrated by Figure 7 below.

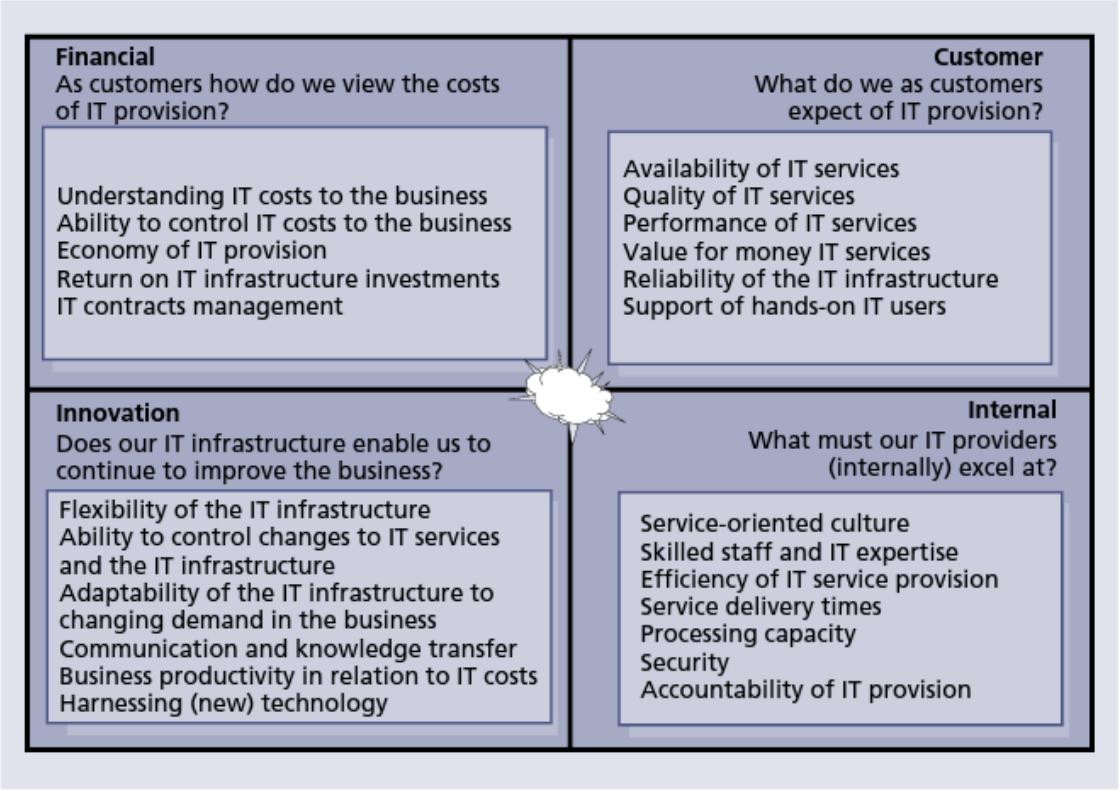

Figure 7: IT balanced scorecard (Cabinet Office 2011, CSI, p. 104)

Petter et al. (2008) claim that the Balanced Scorecard holds promise for measuring the business contribution of IS. Moreover, Martinsons et al. (1999) propose a balanced IS scorecard that consists of four performance dimensions derived from the BSC: a business-value dimension, a user-oriented dimension, an internal-process dimension, and a future-readiness dimension. Figure 8 illustrates this scorecard.

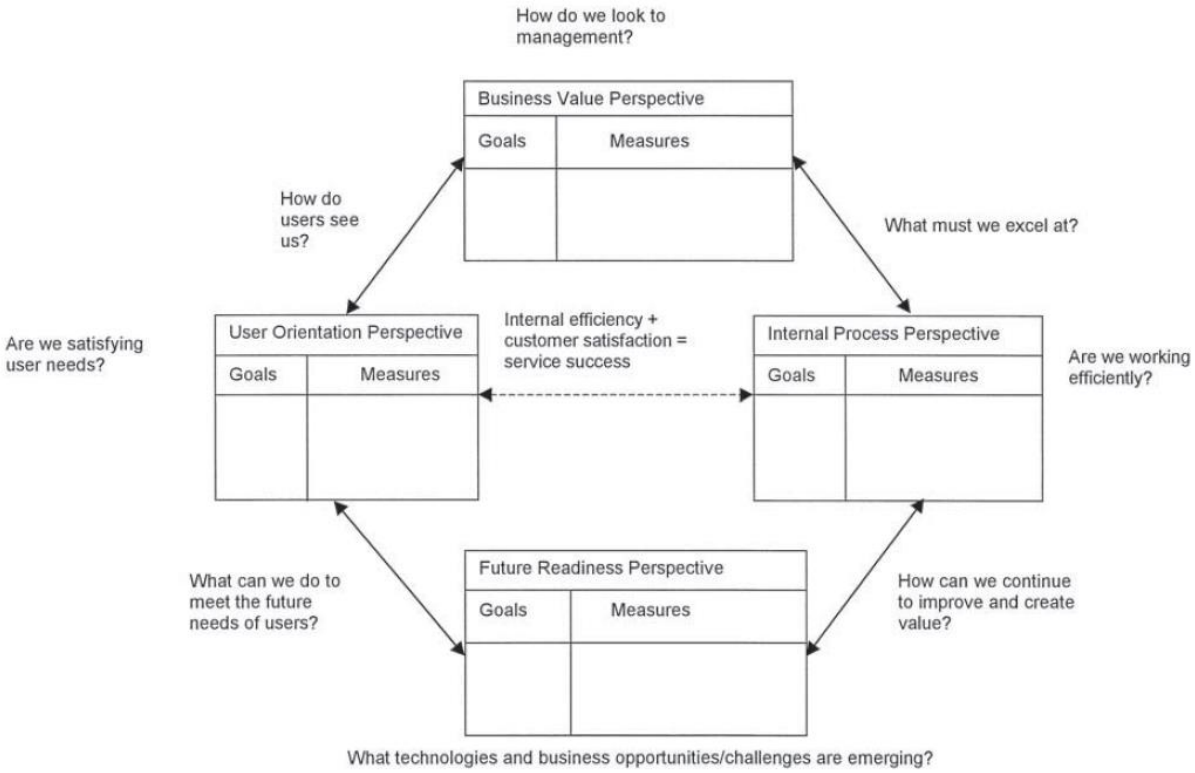

Figure 8: Balanced IS scorecard (Martinsons et al. 1999, p. 77)

2.2.3. The IT Productivity Paradox

Erik Brynjolfsson (1993, p.67) states that "productivity is the fundamental economic measure of a technology's contribution". He, however, remarks that, CEOs and line managers have increasingly begun to question their huge investments in computers and related technologies.

Chan (2000) observes that the relationship between IT and productivity is widely discussed but little understood. Delivered computing power in the U.S. economy has increased by more than two orders of magnitude since 1970 yet productivity, especially in the service sector, seems to have stagnated. It is unclear if information technology actually boosts productivity.

It is, however, evident that the reason for the so called paradox to exist is as much due to deficiencies in measurement methods as to mismanagement of IT. The closer one examines

the data behind the studies of IT performance, the more it looks like bad measurement is at the core of the "productivity paradox". The key problem is how to quantify the holistic effect of IT on organizational performance.

2.3. The value creation process in IS

"Ultimately management exists to maximize value. All else is a means to that end."
– Keen (2011, p.xix)

Melville et al. (2004) observe that despite the importance to researchers, managers, and policy makers of how information technology contributes to organizational performance, the earlier studies of the impact of IT on firm performance provide conflicting findings.

Based on a comprehensive review of the literature and empirical data, the authors conclude that IT is valuable but the extent and dimensions are dependent upon internal and external factors. Using a resource-based view Melville et al. derive an integrative model of IT business value that comprises three domains that each affect the value creation process: 1) focal firm; 2) competitive environment; and 3) macro environment – as illustrated in Figure 9.

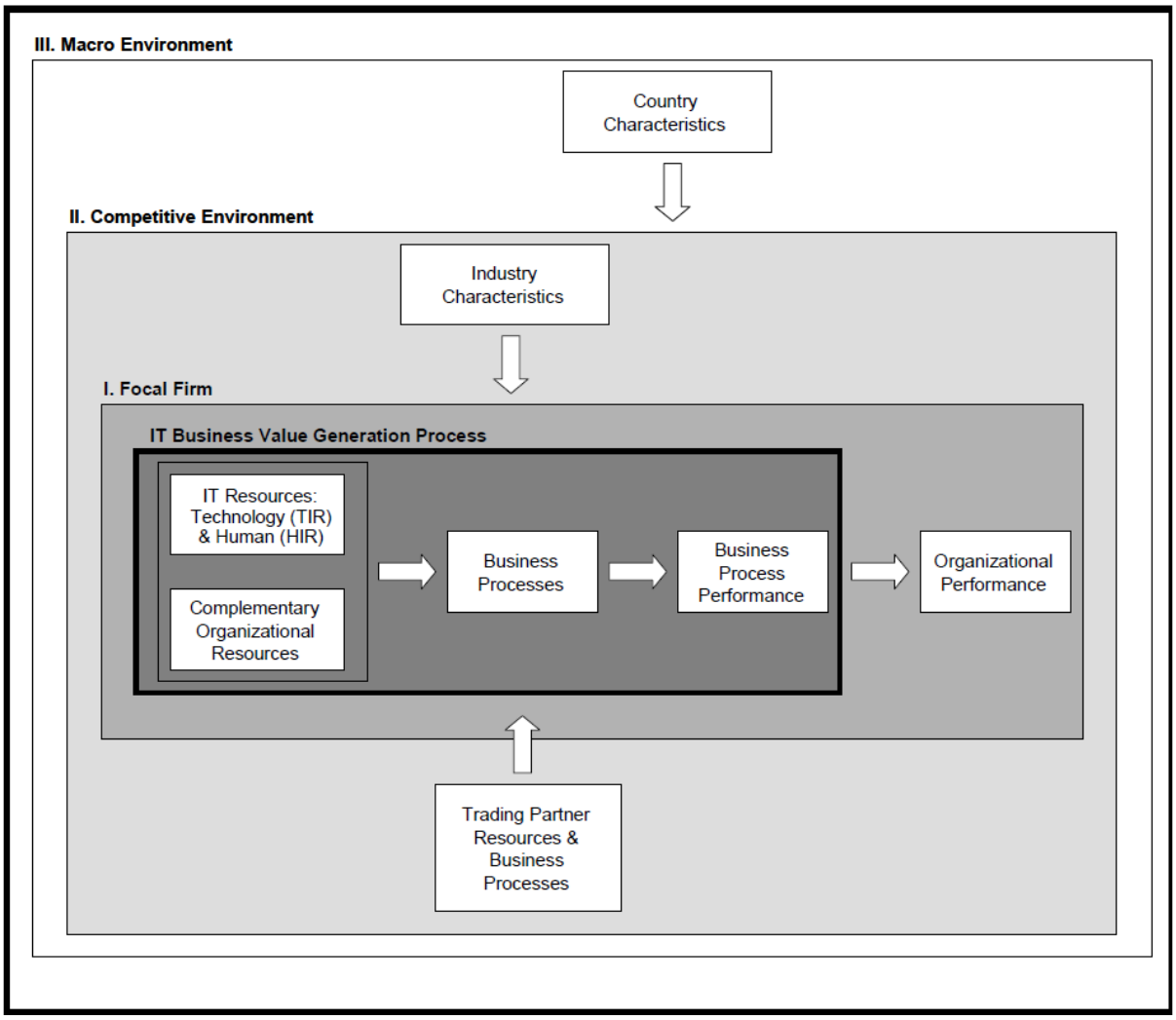

Figure 9: IT Business Value Model (Melville et al. 2004, p. 293)

It is also important to note that the potential value of an information system often differs in practice from the actual realized value. For instance, Keen (2011, p.219) states that surveys throughout decades indicate that, more often than not, expected benefits never appear. That is, forecasting is one thing; realizing benefits is another. Furthermore, Hallikainen et al. (2002) explain that benefits realization in information systems is a long process – especially in the case of intangible benefits. As a consequence, it is more difficult to plan for, forecast, and evaluate IS benefits.

Davern & Kauffman (2000) argue that it is useful to compare the potential and realized value of an IT project in addition to considering expenditures and return on investment. Of particular interest are so called "conversion contingencies" that limit and enable the realization of potential business value. These include, for instance, investments in complementary assets such as user training and business process redesign. In other words, they act as intervening and moderating

factors in the process by which potential is transformed, or fails to be transformed, into realized value. Figure 10 describes this process in more detail.

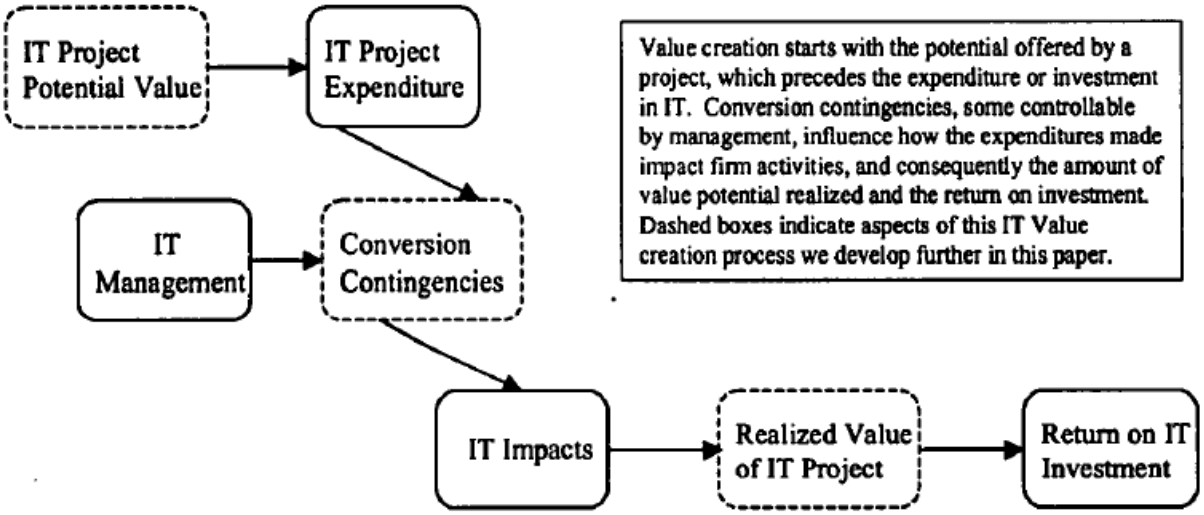

Figure 10: The IT Value Creation Process: From Potential to Realized Value and Return (Davern & Kauffman 2000, p. 123)

Furthermore, the authors introduce a concept called "locus of value" describing the level of analysis at which flows of IT value become discernible for the investing firm. The actual value of the IS will be either easier or more difficult to measure depending on the locus. For instance, the locus of a factory floor automation system would likely be the performance of the factory's operations. However, the locus of value of an electronic banking system would often be split across multiple points of operation, e.g. branch operations, processing operations, and customers (that pay for higher service quality). Moreover, in the value creation process, the locus of potential value might be different from the locus of realized value.

Also the Control Objectives for Information and Related Technology (COBIT) framework takes a look at the value creation process in IS. COBIT is an evolutionary framework/toolset for IT management and IT governance. It has been developed for 15 years by international IT, business, security, risk, assurance and consulting professionals providing their input into what a governance and management framework should provide. In COBIT5, the latest version of the framework, value creation is defined as follows: "Realising benefits at an optimal resource cost while optimising risk" (ISACA 2012, p.15).

Specifically, Val IT framework within COBIT5 addresses assumptions, costs, risks and outcomes related to a balanced portfolio of IT-enabled business investments. Among others, Val IT focuses on measuring IT value delivery. According to ISACA: "the key to value delivery through metrics

is to measure costs and benefits of all organizational entities across their life cycles. Metrics do more than communicate data; they tell others what is thought to be important and what is viewed as a risk or a concern" (ISACA 2011, p.10).

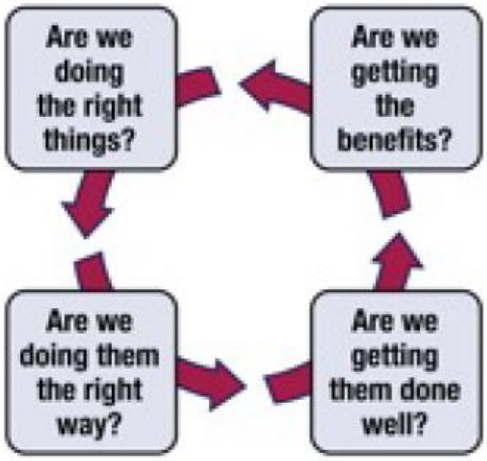

Figure 11: Four Ares (ISACA 2011, p.10)

The Four Ares analysis in Val IT provides a framework to evaluate the value realization from all organizational resources in a holistic manner. It provides a context in which everything is viewed as an investment, and its ROI is calculated on an ongoing basis. The analysis utilizes Dr W. Edwards Deming's (considered by many to be the father of modern quality control) plan-do-check-act (PDCA) cycle as a basis for metrics-based value delivery, as illustrated in Figure 12.

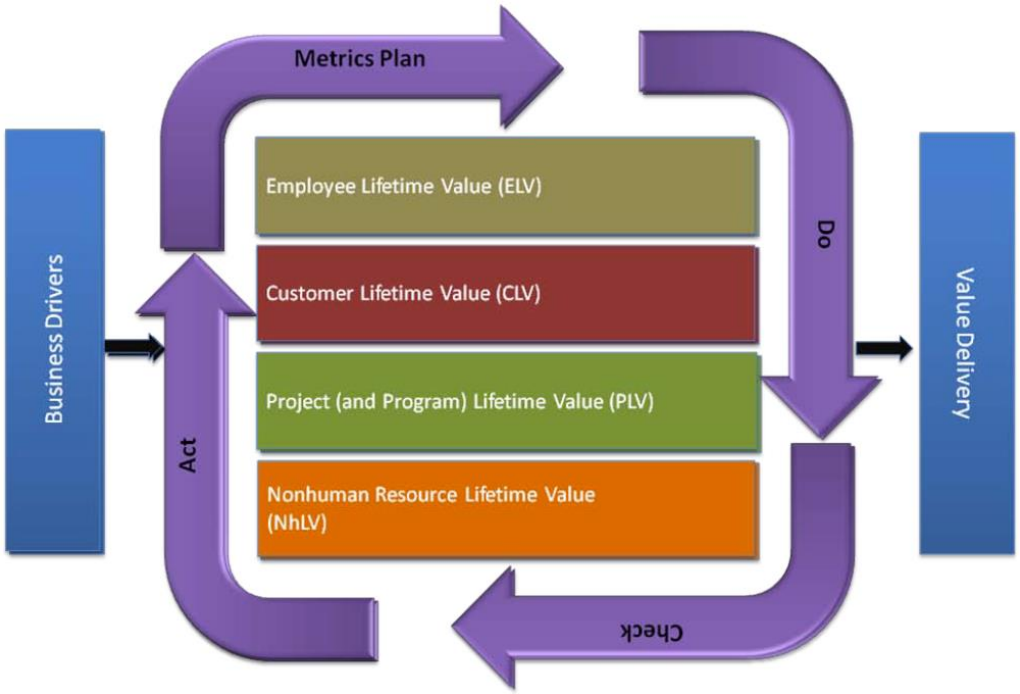

Figure 12: PDCA Cycle of Metrics-based Value Delivery (ISACA 2011, p.11)

According to Tallon et al. (2000), executives are increasingly involved in deciding how, when, and where to use IT resources. In fact, it is their perception that is often used to assess the actual impact of IT, in particular, in the absence of objective data of IT value. It also appears that clear goals for IT investment set by executives, positively correlate with positive value from IT at multiple points along the value chain.

Following these results, the authors observe that management practices play a central role in creating IT business value. Empirical research suggests that, when firms make greater use of post-implementation reviews, executives will perceive higher levels of IT business value. Moreover, there are clear benefits from being able to measure and compare the impacts of a given IT investment against a predefined objective and criteria.

2.4. Measurement systems in evaluating IS quality and success

"If you cannot measure it, you cannot control it. If you cannot control it, you cannot manage it. If you cannot manage it, you cannot improve it. It is as simple as that."
– Harrington (1991) cited in (Nygård 2011, p.1)

The measurement of IS success is critical to our understanding of the value and efficacy of IS investments (DeLone & McLean 2003, p.10). During the last decades, a large number of studies have been conducted in an attempt to identify the factors that contribute to information system success. Moreover, it is evident that software quality plays a key role in achieving IS success (Gorla & Lin 2010, p.603). This section explores the models and methods that contribute to the measurement of quality and success in IS.

According to Petter et al. (2008), the impacts of IS are often indirect and influenced by human, organizational, and environmental factors. Moreover, DeLone & McLean (1992, p.81) assert that attempts to measure the impact of IS on overall organizational performance are not often undertaken because it is difficult to isolate the contribution of a particular system from other contributors to organizational performance.

Nevertheless, this connection is of great interest to the organization investing in IS (DeLone & McLean 1992, p.81). As a matter of fact, in 2008, organizations continued to increase spending on IT, even during possible economic downturns. Behavior like this creates higher risks that have to be managed in order to survive increasing competition. Consequently, organizations are interested in knowing the return on these investments (Petter et al. 2008).

"To measure the success of these various IS, organizations are moving beyond traditional financial measures, such as return on investment."
– Rubin (2004) cited in Petter et al. (2008, p.237)

Petter et al. observe that due to today's pervasive IS, and their tangible as well as intangible benefits, organizations have turned to methods such as balanced scorecards, benchmarking, and models of success. However, the authors argue that while we now understand IS success better, more needs to be done.

2.4.1. A taxonomy of information system success

"If information systems research is to make a contribution to the world of practice, a well-defined outcome measure (or measures) is essential"
– DeLone & McLean (1992, p.61)

Two decades ago, DeLone & McLean (1992) synthesized a six-dimensional taxonomy of IS success based on a review of 180 published conceptual and empirical studies. Since then, the model has been cited and made use of hundreds of times in academic journals. The model consists of six interdependent measures of IS success: *system quality, information quality, use, user satisfaction, individual impact and organizational impact*. In essence, these dimensions represent the intermediate stages on the path leading to the ultimate success dimension: organizational benefits of IS.

System quality is a measure of the information system itself, measuring the performance of the system, and factors affecting it, such as, realization of requirements. Information quality measures the output of the IS, for instance, the quality of the reports produced by the system. Use, on the other hand, is concerned with the way the output of the system is consumed. This is a broad concept, and can thus be considered or measured from several perspectives. Following Use, User satisfaction is measured by the response that the Use of the system's output initiates. Finally, individual impact and organizational impact describe the effect that an information system has on their behavior and performance.

A decade later, DeLone & McLean (2003) updated their success model by reviewing the empirical and conceptual literature on IS success that was published during this period. The authors recognized the proposed modifications to their model and revised the original model accordingly. They decided to add service quality in their updated IS success model claiming

that ‘the changes in the role of IS over the last decade argue for a separate variable – the ‘‘service quality’’ dimension’ (2003, p.18).

Another update to the model addressed the concern over who in the end benefits from IS. Because IS success affects businesses, industries, and even societies DeLone & McLean replaced the variables, individual impact and organizational impact, with net benefits, thereby accounting for benefits at multiple levels of analysis. This revision allowed the model to be applied to whatever level of analysis the researcher considers most relevant (Petter et al. 2008, p.238).

Finally, DeLone & McLean further clarified the “use” construct. The authors explained the construct as follows: ‘”Use” must precede ‘‘user satisfaction’’ in a *process* sense, but positive experience with ‘‘use’’ will lead to greater ‘‘user satisfaction’’ in a causal sense’ (DeLone & McLean 2003, p.23). In other words, increased user satisfaction will lead to a higher intention to use, which will subsequently affect use. The Updated D&M IS Success Model is illustrated in Figure 13.

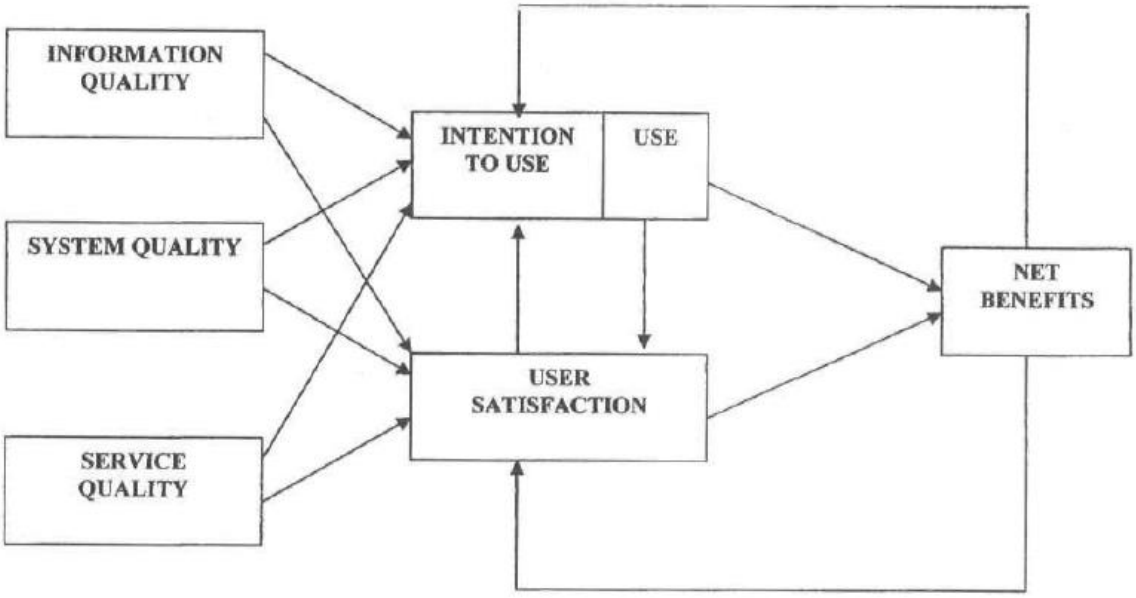

Figure 13: Updated D&M IS Success Model (DeLone & McLean 2003)

The dimensions of success, modified from Petter et al. (2008, p.239) and DeLone & McLean (2003; 1992) are as follows:

- **System quality** – the desirable characteristics of an information system. For example: ease of use, system flexibility, system reliability (no defects), and ease of learning, as well as system features of intuitiveness, sophistication, flexibility, security, and response times.

- **Information quality** – the desirable characteristics of the system outputs (reports, web contents, etc.). Most measures of information quality are from the perspective of the user of this information and are thus fairly subjective in character. For example: relevance, understandability, accuracy, conciseness, completeness, understandability, currency, timeliness, and usability.

- **Service quality** – the quality of the support that system users receive from the IS department and IT support personnel. For example: responsiveness, accuracy, reliability, technical competence, and empathy of the personnel staff. SERVQUAL, adapted from the field of marketing, is a popular instrument for measuring IS service quality (Pitt et al. 1995).

- **System use** – the degree and manner in which staff and customers utilize the capabilities of an information system. For example: amount of use, frequency of use, nature of use, appropriateness of use, extent of use, and purpose of use.

- **User satisfaction** – users' level of satisfaction with reports, web content, and support services. For instance, in e-commerce, covering the entire customer experience cycle from information retrieval through purchase, payment, receipt, and service.

- **Net benefits** – the extent to which IS are contributing to the success of individuals, groups, organizations, industries, and nations. For example: improved decision-making, improved productivity, increased sales, cost reductions, improved profits, market efficiency, consumer welfare, creation of jobs, and economic development. Brynjolfsson et al. (2002) have used production economics to measure the positive impact of IT investments on firm-level productivity.

It important to note that according to DeLone & McLean, it is unlikely that any single, overarching measure of I/S success will emerge. That is why multiple measures are necessary

when evaluating IS success. Moreover, researchers should systematically combine individual measures from the IS success categories to create a comprehensive measurement instrument.

Petter et al. (2008) goes on to clarify that the practical application of the model is dependent on the organizational context. One should always have an understanding of the information system and organization under study. Selection of success measures should also consider the more random variables, such as, the organizational strategy, structure, and size; the technology being employed; and the task and individual characteristics of the system under investigation. For example, an enterprise system application would have some similar success measures and some different success measures compared to an e-commerce application. Both systems would measure information accuracy, while only the e-commerce system would measure personalization of information.

2.4.2. Assessing the organizational benefits of IS

Mirani and Lederer (1998) attempt to measure the organizational benefits of IS projects in an empirical study. The study summarizes major literature contributions in IS benefits, develops a comprehensive list of potential IS benefits, and develops a tool that can be used to analyze the potential benefits of any IS project as well as compare the anticipated benefits of a project with its realized benefits. The final list of IS benefits is listed in Table 2.

Table 2 Organizational benefits of IS

Strategic Benefits
Competitive Advantage
Enhance competitiveness or create strategic advantage.
Enable the organization to catch up with competitors.
Alignment
Align well with stated organizational goals.
Help establish useful linkages with other organizations.
Enable the organization to respond more quickly to change.
Customer Relations
Improve customer relations.
Provide new products or services to customers.
Provide better products or services to customers.

Informational Benefits
Information Access
Enable faster retrieval or delivery of information or reports.
Enable easier access to information.
Information Quality
Improve management information for strategic planning.
Improve the accuracy or reliability of information.
Improve information for operational control.
Information Flexibility
Present information in a more concise manner or better format.
Increase the flexibility of information requests.
Transactional Benefits
Communications Efficiency
Save money by reducing travel costs.
Save money by reducing communication costs.
Systems Development Efficiency
Save money by reducing system modification or enhancement costs.
Allow other applications to be developed faster.
Allow previously infeasible applications to be implemented.
Provide the ability to perform maintenance faster.
Business Efficiency
Save money by avoiding the need to increase the work force.
Speed up transactions or shorten product cycles.
Increase return on financial assets.
Enhance employee productivity or business efficiency.

2.4.3. Determinants of IS quality

"If you can't measure it then you can't manage it"
– ITIL, Service design (2011)

Nelson et al. (2005) state that quality has evolved into a core business concept that has dramatic implications for business value. The authors observe that some researchers assert

that quality of products and services is the single most important determinant of a business' long-term success.

In an empirical study, Nelson et al. examine their model (illustrated in Figure 14) that explains how various system and information attributes influence information and system quality and, ultimately, user satisfaction. As a result, it appears that the model is indeed predictive of overall information and system quality. However, it is empirically tested only in a data warehouse context.

The study by Nelson et al. suggests that there are stable attributes that can be managed to influence quality, and that these attributes should be primary concerns in system design. On the other hand, Gorla & Lin (2010) argue that organizational factors might be more important than technical factors in impacting software quality in IS.

Gorla & Lin propose a list of organizational, individual, and technological variables that may influence software quality (Table 3). The variables are inter-related. For example, higher turnover of users can give rise to more change requests to the system, which may require higher IS budget in the future – which depends on the organizational hierarchy. Moreover, the higher the level of user involvement in system development, the lower will be their resistance to change due to new IS.

Indeed, organization's level of commitment appears to be one of key determinants of IS quality. This perception is also supported by Stylianou & Kumar who see bad quality as a byproduct of lacking culture: "Unfortunately, it seems that despite the importance of IT to the success of most organizations, the function is not proactive when it comes to actively pursuing and implementing quality principles" (Stylianou & Kumar 2000, p.99).

Also Crosby (1994, p. xi) identifies the same challenge. He states that the problem of quality has always been management's lack of understanding of their responsibility for causing a culture of prevention in their company. That is what quality management is supposed to do. It is a matter of determining exactly what the customers (both internal and external) want; describing what has to be accomplished in order to give that to the customer; and then meeting those requirements every time.

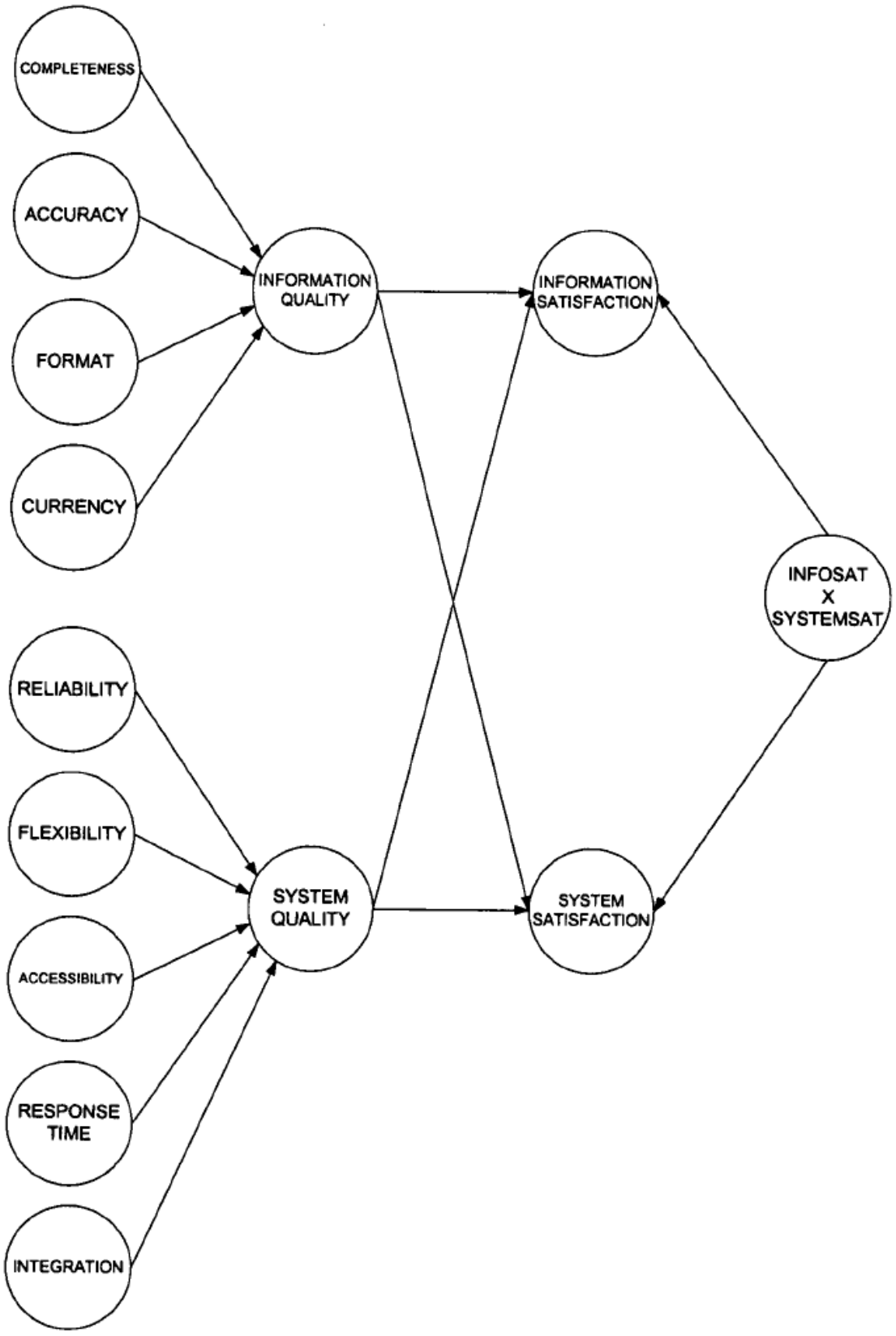

Figure 14: Determinants of Information and System Quality (Nelson et al. 2005, p. 208)

Table 3 Organizational, individual, and technological variables (Gorla & Lin 2010)

Type of variable	Variable
Organizational	Top management support
	Rank of IS manager
	Experience of IS manager
	IS budget
	Number of people in system development
	Turnover in IS department
	Quality of documentation
	Frequency of users' change requests
	Turnover in user groups
	Number of people in company
Individual	Level of user involvement
	User resistance to change
	User competency
	User knowledge of systems
	User training in systems
Technological	Experience of IS staff
	Skill level of IS staff
	Support from IS department
	Type of development method used
	Suitability of development method
	Type of programming language
	Suitability of programming language
	Type of database model used
	Suitability of database model

2.4.4. Choosing the appropriate metrics

"The challenge for the IS function is to first identify all the stakeholders and their quality concerns, and then integrate all the measures and metrics from the various groups. – Stylianou & Kumar (2000, p.102)

The research by Stylianou & Kumar (2000) supports the conclusions of Gorla & Lin. Stylianou & Kumar suggest that the impact of organizational investments in IS quality may vary depending on organizational factors such as culture, politics, and senior management support. Moreover, perceptions of quality may also vary between stakeholders, depending on those factors. Departmental factors such as differences in leadership style, employee skills, and IT intensity also impact IS quality perceptions and management. Consequently, when choosing metrics for IS quality, weights should be assigned by each stakeholder group.

As described in section 2.1.2 of this Master's thesis, Stylianou & Kumar present an integrated view of IS quality management. Furthermore, Stylianou & Kumar describe a process of gathering and integrating quality attributes from multiple stakeholders. The authors maintain that quality attributes and metrics play an important role in establishing quality levels, benchmarking, and continuous improvement. Moreover, one should utilize the guidelines provided by different quality standards (e.g. ISO 9000) and evaluation frameworks (e.g. the Capability Maturity Model) for establishing quality attributes and metrics. Table 4 provides illustrative quality attributes and metrics for some IS processes.

Table 4 Example quality attributes and metrics for IS processes

Process	Attributes	Metrics	Quality Dimension
System Development	Cost	$ per person hour, # of person hours	Administrative Quality
	Time	Days	Administrative Quality
	Bugs	# of system crashes, # of minor faults	Data, Software, Infrastructure Quality
	Ease of use	# of requests for help, learning time	Information Quality
	User satisfaction	Survey instruments	
System Maintenance	Ease of fixing problems	Response time for maintenance requests	Service Quality
Problem resolution time	Service Quality		
Budgeting	Cycle time	Days	Administrative Quality
	Responsiveness to changes	Frequency of review (weeks) Systematic procedures for project review and incremental commitment	Administrative Quality

Neely et al. (2005, pp.1229–1230) suggest that it is possible to analyze a measurement system by asking questions related to each level of the system. The individual measures can be analyzed by asking questions such as:

- What performance measures are used?
- What are they used for?
- How much do they cost?
- What benefits do they provide?

The system as an entity can be analyzed by asking:

- Have all the appropriate elements (internal, external, financial, non-financial) been covered?
- Have measures which relate to the rate of improvement been introduced?
- Have measures which relate to both the long- and short-term objectives of the business been introduced?
- Have the measures been integrated, both vertically and horizontally?
- Do any of the measures conflict with one another?

Nygård (2011) asserts that it is more important to figure out a way to build metrics rather than try to fit standard metrics to every process.

2.5. Theoretical framework

The theoretical framework that has been discussed in this Chapter provides a cornerstone for this research. These topics form an important source of information on which the study will build. The final conclusions of the research will be derived both from the theoretical framework and from the findings in the empirical study.

The literature review consolidates existing academic and professional research on concepts, theories, models, and methods concerning quality in information systems. In addition, measurement systems in relation to investments and measurement systems in relation to IS quality and success (business value) are discussed. These three topics interact with each other as shown in Figure 15.

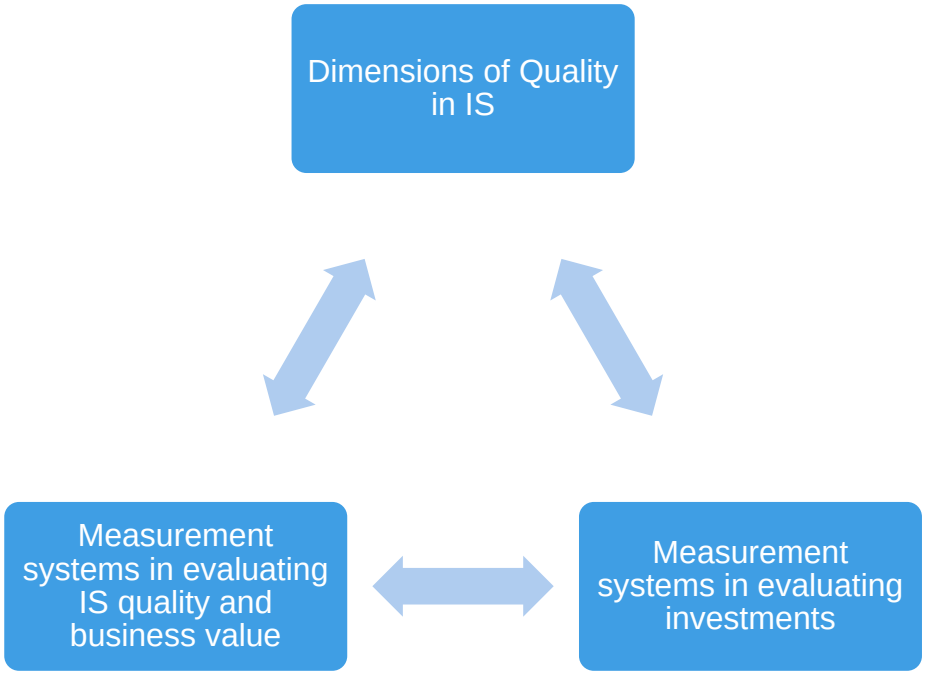

Figure 15: Theoretical Framework

3. RESEARCH METHODOLOGY

The theory of this study is based on a critical literature review on the related academic literature including but not limited to various methods, tools, models, and frameworks surrounding the topic. Emphasis will be on research that already has some empirical findings.

The academic research in the field is fairly young as it dates back only a few decades. Moreover, since the scope of the study is very broad, the number of articles and other sources is considerable. At this point, I have gone through a significant amount of literature, and omitted many potential sources in order to produce as concise research as possible in the end. I have used some articles that do not deal with the issues in my topic specifically but give background information to get a clearer picture of the matter. However, most of the sources used are directly relevant and comprehensive in nature.

The research approach in the study is based on constructive research. The motivation for using this method is that it is suitable to provide answers for questions ‘how’ and ‘what’, multiple sources of evidence are used, and that the study has a strong practical focus as it is solving a practical problem.

The third research objective (constructing a model) will be met by either applying or extending an existing model or by creating a completely new model based on the constructive research.

3.1. Constructive research

Constructive research is a management accounting research method described by Kasanen et al. (1993). The constructive approach is characterized by dividing the research process into phases, the order of which may vary from case to case:

1. Find a practically relevant problem which also has research potential.

2. Obtain a general and comprehensive understanding of the topic.

3. Innovate, i.e., construct a solution idea.

4. Demonstrate that the solution works.

5. Show the theoretical connections and the research contribution of the solution concept.

6. Examine the scope of applicability of the solution.

Innovation and creativity are core elements of a successful constructive study. Kasanen et al. state that "if the researcher is not able to produce any new solution to the problem in question, then there is obviously no point in going on with the study" (1993, p.247). Moreover, the final solution from the constructive process should be tested in practice.

Figure 16: Elements of constructive research (Kasanen et al. 1993)

3.2. Information collection

Information was collected according to the guidelines of the constructive research approach. The main data sources were the academic research databases that Aalto University has access to. Thus, most of the information collected was in a digital format. All of the sources were archived in a research database, and a taxonomy of information was created. Thus, allowing quick searches into all of the data.

3.2.1. Interviews

According to Yin (2009), interviews can provide rich causal inferences and explanations. Moreover, they are insightful and targeted. However, interviews can suffer from poor questions, and there can be biased responses as interviewees recall things differently and do not or are not able to reveal all of the relevant information.

In order to answer the second research question – find out how companies currently measure their investments in IS, and how this relates to their perception of quality – interviews were conducted. The interviewees were chosen from among Qentinel's customers. The companies were all large Finnish corporations with a turnover ranging from EUR 99 million to EUR 766 million, and amount of personnel from 450 to over 2000. Each interviewee was in a position to make decisions concerning investments in information systems. Interviewee titles ranged

from Project owner to Development manager, Project portfolio manager, IT Service Manager, Program Director, and CIO.

In total six interviews were conducted, in a semi-structured manner. Semi-structured format was chosen because an open interview allows new ideas to be brought up during the interview. Each interviewee was interviewed once. All interviews were made face-to-face. There were 2 hours reserved for each interview. The interviews were all recorded. The interview structure can be found in Appendix A.

3.3. Research integrity

This study uses documentation, interviews, and direct observations to improve construct validity. However, due to the large scope of the study, the approach to the research process has been rather theoretical, and the topic has been approached in a deductive manner. In order to enhance the integrity of the study, the majority of the literature sources that are referred to are built on empirical data such as case studies. Moreover, findings from the interviews are compared with the findings from the literature. The information that is used in this study is considered reliable since the authors of the sources are mostly academically recognized professors and researchers. Efforts have also been made to ensure the validity of the thesis by critically examining all of the sources.

4. EVALUATING INVESTMENTS & QUALITY IN CASE COMPANIES

The chapter builds on the literature review and introduces new real-world data to the research that is then discussed and analyzed in the next chapter.

4.1. Building the interview

The interest of the interview for this thesis was twofold: 1) to find out how do Finnish companies currently measure their investments in IS, 2) to find out how do these companies perceive quality in IS. Moreover, the interviews served this study by bringing in new real-world data and making it possible to compare the current state of research (the literature review) with the current state of things in the business world. In addition, the interview served Qentinel in creating a better understanding of customers and their needs in measuring the quality of IS and their investments in IS.

The interview was built based on the research objective and research questions of this study as well as the main findings from the literature reviewed. Three main topics were chosen. In addition, it was hypothesized that interviewee perceptions about current models of evaluating IS value would be beneficial. Therefore, a fourth topic where the interviewee would comment on current models was introduced to the set of questions in the interview.

4.2. Findings

This section summarizes the findings from the interviews. The findings should answer research question 2 and prepare for the analysis in Chapter 5.

4.2.1. Expectations from information systems

All of the interviewees deemed information systems as critical for their business. This was partly due to the character of their clientele as they were in consumer business were “in order to be competitive one has to have a certain level of IT systems”. In addition, IS’ importance in supporting business was highlighted.

The interviewees had somewhat similar expectations of information systems. The common benefits of IS, such as, increased automation, saved time, greater efficiency, lower costs in operations, and process support were mentioned. Moreover, IS’ role in creating new business,

new services, and increased revenue was apparent. Information systems were seen as enablers of business development.

4.2.2. Evaluating the value of information systems

Based on the interview, it seems that measuring and evaluating the value of information systems is a rather difficult topic for Finnish companies. None of the interviewees were measuring IS value comprehensively nor continuously. Moreover, it appears that only few people in the organizations have a good understanding of the importance of measuring IS value.

The most common way of evaluating IS value was to define a business case before the IS project actually starts. Based on this, the project would either start or be abandoned. However, none of the six interviewees would measure the realization of the business case benefits after the project even though measuring costs would be common.

According to the interviews, the value of information systems is evaluated non-systematically and with varying metrics. Metrics that are currently in use include, among others: end-to-end process measurement, ROI, user satisfaction, costs, number of new clients, new revenue, availability of service (often defined in an SLA – Service Level Agreement), response time, and company image. Monetary metrics are rather strongly preferred but also soft metrics are appreciated.

Furthermore, it appears that it is often unclear who is responsible for IS value-creation. While business and IT both measure IS usually in some way, metrics specifically for value/benefits do not have a common owner. The answers for this specific question were as follows:

1. Business, process owners
2. People in another country
3. Product owner (after project has been completed -- the project is not responsible for the actual benefits realization)
4. Unclear
5. Business
6. Corporate management group

The reason why evaluating value of information systems is manifold. Metrics concerning value are often difficult to isolate. For instance, it is difficult to explain the causal relationship between a web site response time and its effect on IS value. Thus, technical measures without linking them to business value are easier. Moreover, when a measurement plan for value/benefit realization is not defined at the beginning of the project and no one is responsible for it, measurement just does not happen.

4.2.3. Quality in information systems

In general, quality was seen as satisfying the intended purpose. That is, good quality does not need to be visible – in fact, it is often invisible. It results in low defects, easy maintenance, cost-effectiveness, and good end-user experience. Bad quality, on the other hand, is very visible and results in high costs. In fact, one of the interviewees concluded that "bad quality can obliterate benefits". In addition, quality is important in optimizing risk - realizing benefits is possible at an optimal resource cost only through good quality.

Quality is hard to measure, and it is difficult to define goals for quality. It means different things for different people, and it is rather hard to link it directly to business value. In the opinion of the interviewees, quality is also a topic that is hard to talk about.

In order to reach good quality, an IS project needs good people, excellent requirements planning, and investments in quality assurance. In the context of IS, these investments were seen mostly as investments in testing and technical implementation rather than in measuring quality holistically.

4.2.4. The need for new methods and practices

It can be concluded that based on the interviews, there is a need for new methods in evaluating the value of information systems. Moreover, there is a need to measure IS more comprehensively – even without linking the metrics to value. In one of the interviewed companies there was a project under way to develop new methods of measuring IS benefits.

End-to-end measurement where one measures a process from beginning to end was seen as one of the most promising and effective ways of measuring. In addition, perceived quality was deemed highly important. Common ways of measuring perceived quality include user satisfaction, client satisfaction, employee satisfaction, and even employee morale. It is,

however, important that the measurement results represent reality as guesses can prove to be dangerous for a business.

The desired state for measuring IS value would be that it is a normal and continuous convention rather than a random onetime event. Systematic measurement would serve the business also by improving the communication between IT and business. Current state of things is often that IT is fragmented in silos and everything is organized by cost centers – not by how IT is consumed by the business.

The Quality scale model was seen as a good way of describing quality and its dimensions. It was suggested that one could define metrics for each dimension to holistically measure quality and value.

5. EVALUATING THE BUSINESS VALUE OF GOOD QUALITY

The current concepts, theories, models, methods, and empirical results about quality in information systems provide a rather broad view to quality and its importance in IS. Definitions of quality also vary in their usefulness to managers. Quality can be compared with other similarly elusive constructs such as intelligence, leadership, or motivation. No universal definition of quality applies to all products and all services in all industries, and such is the case in the ICT industry as well.

Most industries today are IT-intensive because of the large number of IS-supported processes and the high degree of integration between IS and business processes. Our world runs on software. Every business depends on it, every mobile phone uses it, and even every new car relies on code. Without software, modern civilization would fall apart. Given this reality, the quality of that software really matters. Because it is so widely used and so important, low-quality software just is not acceptable. Consequently, managing IS quality and IS business value is extremely important.

There is a clear consensus that quality is important but definitions of quality in IS depend on the context and point-of-view. On the other hand, the interviews in this study present a slightly more unified perspective to quality, and quality is almost unanimously defined as satisfying the intended purpose. Good quality is seen as something that is almost invisible. Table 5 presents a summary list of quality dimensions and quality attributes that emerged during the study.

Table 5 Summary of quality dimensions and quality attributes in IS

Dimension of quality	Quality attributes
Technical quality	Complies with known requirements
Structural quality	Conformance to specifications
Information quality	Information accuracy
System quality	Information conciseness
Internal quality	Information completeness
Infrastructure quality	Information currency
Software quality	Information format
Data quality	Information flexibility
Standards quality	Accessibility
Legal quality	Reliability
	Flexibility
	Integration

	Adaptability
	Maintainability
	Complexity
	Size
	Amount of rework, waste
	Amount of technical debt
	Amount of failures
	Amount of defects
	Amount of warranty claims
	Amount of tickets
	Response time
	Performance
	Availability
	Security
	Sophistication
	Test coverage
Process quality	Well implemented and operated
Service quality	Process efficiency
Administrative quality	Quality of planning
	Quality of budgeting
	Quality of scheduling
	Quality of customer processes
	Quality in testing
	Quality in production
	Technical competence
	Empathy of the personnel
	Project lead-time
	Time to market
	Innovation
	Transparency
	Systems development efficiency
	Effective defect prevention methods
	Management commitment
Perceived quality	Approved by end-users
Aesthetic quality	Meeting customer expectations

External quality	Exceeding customer expectations
Intention to use	Excellence
System use	Usability
	Reliability
	Ease of use
	Ease of learning
	Intuitiveness
	Amount of use
	Frequency of use
	Extent of use
	Nature of use
	Appropriateness of use
	Purpose of use
	Information understandability
	Information timeliness
	User satisfaction
	Client satisfaction
	Employee satisfaction
	Employee morale
	Individual impact
	Company image
Usefulness	Meets business needs
Net benefits	Improved effectiveness
Organizational impact	Increased efficiency
	Increased productivity
	Better access to information
	Relevance
	Improved decision-making
	Decreased costs
	Increased profits
	Increased market share
	Increased number of customers
	Meet competition
	Create competitive advantage
	Increased customer satisfaction
	Secure premium prices

	Increased sales income
	Improved delivery performance
	Improve IT business alignment
	Communication efficiency
	Consumer welfare
	Creation of jobs

The academic research on evaluating IS business value deals with topics in performance measurement and IS value creation. There are similarities in how the research community evaluates investments in business and investments in IS. For instance, balanced scorecard is used in both contexts. Moreover, it is evident that measuring IS performance is difficult both due to deficiencies in measurement methods as well as deficiencies in management. The value of information systems is realized at different times and in different ways for different stakeholders. Thus, it is also difficult to forecast IS' potential value, and it can appear that expected benefits never appear.

Measurement systems in evaluating IS quality and success are, in general, related to the measurement of IS business value. It appears that the research community sees investments in quality as investments toward creating intended net benefits. Similarly, the interviews in this study support this conclusion. However, more often than not, investments in quality are only measured from a technical perspective. According to the research results, investments in complementary assets (e.g., management skills, user training, and application of standards) are also critical to understanding the return on IS investments.

Based on the literature view and the interviews conducted in this study, this study ultimately takes a restricted approach to quality; namely, a business value approach to information system quality where quality refers to the ability of the information system to create the intended business value. This approach is illustrated in Figure 17.

Quality refers to the ability of the information system to create the intended business value.

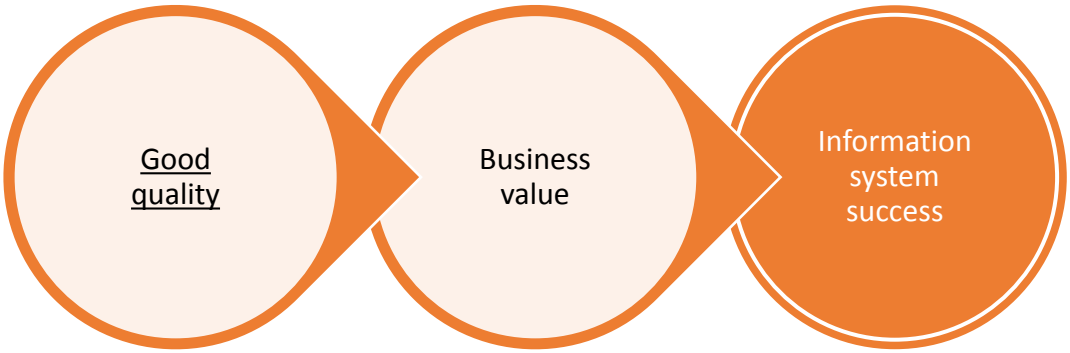

Figure 17: A business value approach to information system quality

It can be concluded that no management process exist that would ensure the realization of IS business value. Benefits are more certain when management monitors value every step of the way, from project funding through the system retirement. Moreover, measurement plays an important role in successful management, in establishing quality levels, in benchmarking, and in enabling continuous improvement. There are clear benefits from being able to measure and compare the impacts of a given IT investment against a predefined objective and criteria. Therefore, in order to successfully manage IS business value realization there is a need for a new measurement instrument.

5.1. A model for evaluating the business value of good quality in IS

The model presented in this section has strong influences from The meanings of Quality (Juran 1999), the Balanced Scorecard (Kaplan & Norton 1996), the IT Business Value Model (Melville et al. 2004), the "locus of value"-concept (Davern & Kauffman 2000), Val IT framework (ISACA 2011), D&M IS Success Model (DeLone & McLean 2003), and the Quality Scale (Qentinel Ltd. 2011), and the summary of quality dimensions and attributes described in Table 5. In other words, the model has a number of different methods, models, and concepts as its background.

This study proposes a model illustrated in Figure 18 as a tool for evaluating the business value of good quality in IS. The model recognizes the nature of quality in that quality has many dimensions, it can be interpreted in a number of ways, and that quality is an important success factor. The following paragraphs describe the rationale and use of the model.

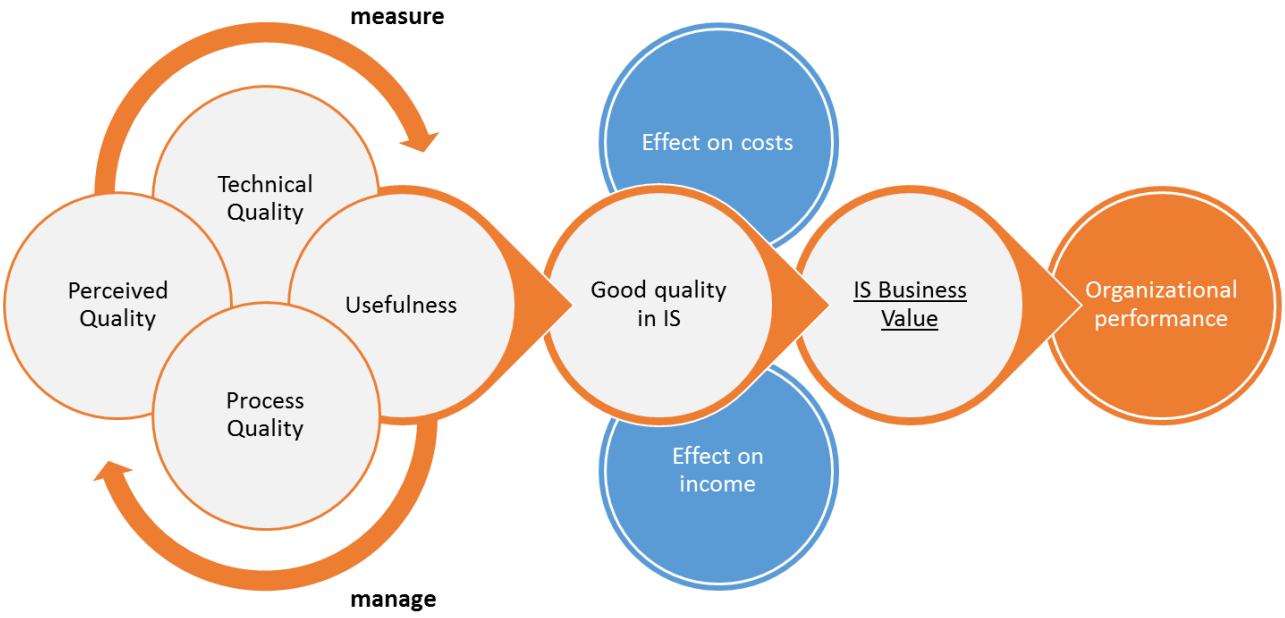

Figure 18: A Model for Evaluating the Business Value of Good Quality in IS

The dimensions of quality together represent all of the preconditions for good quality in information systems. All of the dimensions need to be of intended quality in order for the information system to be of good quality.

Applying the assessment criteria described in section 2.1, it can be concluded that these dimensions *enhance understanding* of the multifaceted nature of quality in IS. They take into account the intrinsic, extrinsic, and representational views of quality and emphasize the importance of context and perception in the overall quality assessment. The dimensions are *actionable* in that they can guide a decision-maker to refine specific features of a system in an effort to enhance quality, and the dimensions are relatively *parsimonious*, distilling 21 dimensions of quality represented in the literature and the empirical data (see Table 5, dimensions of quality) into four key constructs. They are also *measurable*. What remains to be determined is the extent to which the dimensions are *complete and predictable*.

Process quality emphasizes the importance of the processes in both the development and operation of the system, such as, project management that follows budget and schedules, methods in testing, and transparency in the process-flow. Good p**erceived quality** requires that the information system is approved by the end-users. In other words, this dimension includes

attributes such as ease of use, amount of users, and overall user satisfaction. **Technical quality** refers to the technical requirements that a system might have, such as, response time, maximum number of bugs, and performance. That is, the system should comply with the known requirements. **Usefulness**-dimension emphasizes that an information system is always created based on business needs. That is, the information system should meet these needs.

Each quality dimension should have its own goals and metrics, depending on the context. Table 5 lists example metrics that can be used in each dimension. It is also important to note that the dimensions of quality should inherently take into account different stakeholder views when defining metrics. The continuous measurement of quality dimensions is important for two reasons: 1) In order to manage something one needs to measure it. That is, in order to reach the intended quality goals measurement is vital; 2) Requirements in IS change continuously according to business needs – usually in an agile manner. Therefore, one should be able to compare the quality goals to the current business needs, preferably in real-time.

As we move forward in the model, the effects of good quality on the organization's revenue logic are highlighted. **Effect on costs** emphasizes the cost effects that good quality has. Good quality is often more expensive to create due to higher prevention costs but it is cheaper in the long-term due to lower failure and maintenance costs. Further, **effect on income** includes all of the positive effects that good quality generates. That is, when the information system is of good quality, and operates as intended, it realizes the value of the IT project and generates a return on investment. In addition, good quality software can have other positive income effects that were not intended, such as, a positive effect on customer retention or company image, and consequently, a positive effect on income. In other words, *the whole is greater than the sum of its parts*. These effects can usually be expressed in monetary terms. However, depending on the context, costs and income can also be expressed in non-monetary terms. For instance, in a hospital, costs could be lives lost and income lives saved.

IS Business Value is then derived from the previous elements in the model. As defined in the Introduction, this study considers IS business value as the organizational performance impacts of information systems at both the intermediate process level and the organization wide level, and comprising both efficiency impacts and competitive impacts. That is, in the end, the business value of good quality in information systems is examined from the point of view of the entity that makes the financial investment in the system.

The model may be applied by both business and IT management but should preferably be applied by both in cooperation to include all stakeholder views.

6. CONCLUSIONS

This study was conducted in order to understand how one could evaluate the business value of good quality in information systems. In order to find an answer to the research question three research objectives were set, presented in section 1.2. Constructive research was used as a research method. As a result, a model for evaluating the business value of good quality in IS was constructed.

6.1. Main findings

Good quality is a precondition for reaching the intended IS business value. Increasing dependence on information systems and the huge costs of poor quality software draw management's attention towards software quality improvement. However, no management process exists that would ensure the realization of good quality. In other words, although information systems are different from case to case and very context dependent it is important to make to effort to compare them with each other and assess how they realize the intended value.

Examining prior reviews of the literature made a compelling case for defining what good quality in IS means as there is still no consensus in the research community as to what quality in IS represents. The current academic research about quality in information systems provide a rather broad view to quality and its importance in IS. Definitions of quality also vary in their usefulness to managers.

Furthermore, information systems evaluation is a thorny problem. Organizational issues make evaluation difficult as the context in which IS are developed and used has become much more demanding and complex. More specifically, the value of information systems is realized at different times and in different ways for different stakeholders. However, it is clear that IS evaluation is necessary. There are clear benefits from being able to measure and compare the impacts of a given IT investment against a predefined objective and criteria.

This study proposes a model that can be used as a tool for evaluating the business value of good quality in IS.

6.2. Practical implications

The model developed in this study allows business decision-makers to ensure the value of information systems. It presents a comprehensive understanding of IS quality that can be measured and managed. Furthermore, the model creates a starting point for defining continuous

quality measurement and improvement plans for information systems. The model also allows companies to set better goals for IT projects and to unify their expectations. In practice, the model could be used as a basis for creating new measurement systems about IS business value.

The model provides relevant managerial implications as it holds the potential, if examined properly, to enhance the operating performance of any firm. Especially managers and decision-makers involved in knowledge-intensive businesses could benefit from this more consolidated approach to information system quality. By explicitly identifying the quality definition they are using, managers are better able to move organizations toward the achievement of quality, and researchers can make progress toward assessing the impact of quality on organizational performance and other variables of interest.

Value is maximized when projects are completed not only "on-time" and "on-budget" but "on-value". This research can help drive world class organizations with greater IS effectiveness, better IT business alignment, and lower cost. Moreover, better management of IS business value can materialize as improved risk management, improved business-IT communication, improved delivery of business objectives, and improved business competitiveness.

6.3. Limitations of the study

This study used documentation, interviews, and direct observations in order to improve validity. The theory uses a large amount of recognized sources, which can be considered to increase construct validity. There could have been a larger number of interviews, but already six interviews showed clear signs of saturation of opinions. The interviewees were carefully selected. Finally, the university supervisor and company supervisor reviewed a draft version of the work. To conclude, the validity of the study can be seen as good.

The model developed in the study is still lacking empirical verification. The model should be verified by executing measurements, collecting data, and verifying the causal relationships (including correlation) between the elements in the model, and then updated accordingly. As a conclusion, the validity of the model can be seen as fair.

6.4. Suggestions for further research

This study has introduced new empirical data, and come up with a fresh and business-based practical approach to evaluating IS quality and IS business value. Future research should utilize

the conclusions of this study, and empirically evaluate and further develop the model that was introduced.

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8. APPENDIX A: Interview template

GENERAL

- Could you, please, tell me about your background and current position in company X?
- How are information systems (IS) related to your work:
    - How do information systems affect you work?
    - How do you affect information systems?

EXPECTATIONS FROM INFORMATION SYSTEMS IN YOUR COMPANY

- What kinds of business benefits/value does your organization look for in IS?
- How do you strive to verify/evaluate/measure these in practice?
    - When do you measure?
    - Who is responsible?
- What would you say is the BEST way of measuring IS business value?

EVALUATING THE VALUE OF INFORMATION SYSTEMS

- What do you think is important when choosing measurement methods?
- How could measurement be continuous?
- What would you say is a good metric for value?
    - What should you measure/not measure?
    - How should you measure/not measure?
    - How do you perceive measuring intangible benefits?
- What do you think is the relationship between the benefits created by IS and the quality of IS? Can you measure project success by measuring project quality?

QUALITY IN INFORMATION SYSTEMS

- How would you define *quality* in the context of IS?
    - What other word could you use?
    - How would you describe the dimensions of quality?
    - What would you say is the difference between good and bad quality?

- What kinds of expenses can you identify related to information systems?
- Why are these expenses necessary?

- How do you strive to verify/evaluate/measure quality in practice?
    - Why should it be measured/not measured?
    - Are there certain goals/criteria set specifically for quality?
    - When do you measure?
    - Who is responsible?

- What would you say is the BEST way of measuring IS quality?
- If you would have unlimited resources in improving quality, how would you use these resources / what would you do first?

CURRENT MODELS IN EVALUATING INFORMATION SYSTEM VALUE

- What do you think of the statement: ”Information system quality refers to the ability to create the intended business value?”

- What is your opinion of the following model where tangible and intangible metrics are combined and transformed into monetary measures in order to evaluate ROI?

TABLE IV
CLASSIFICATION OF SPI BENEFITS

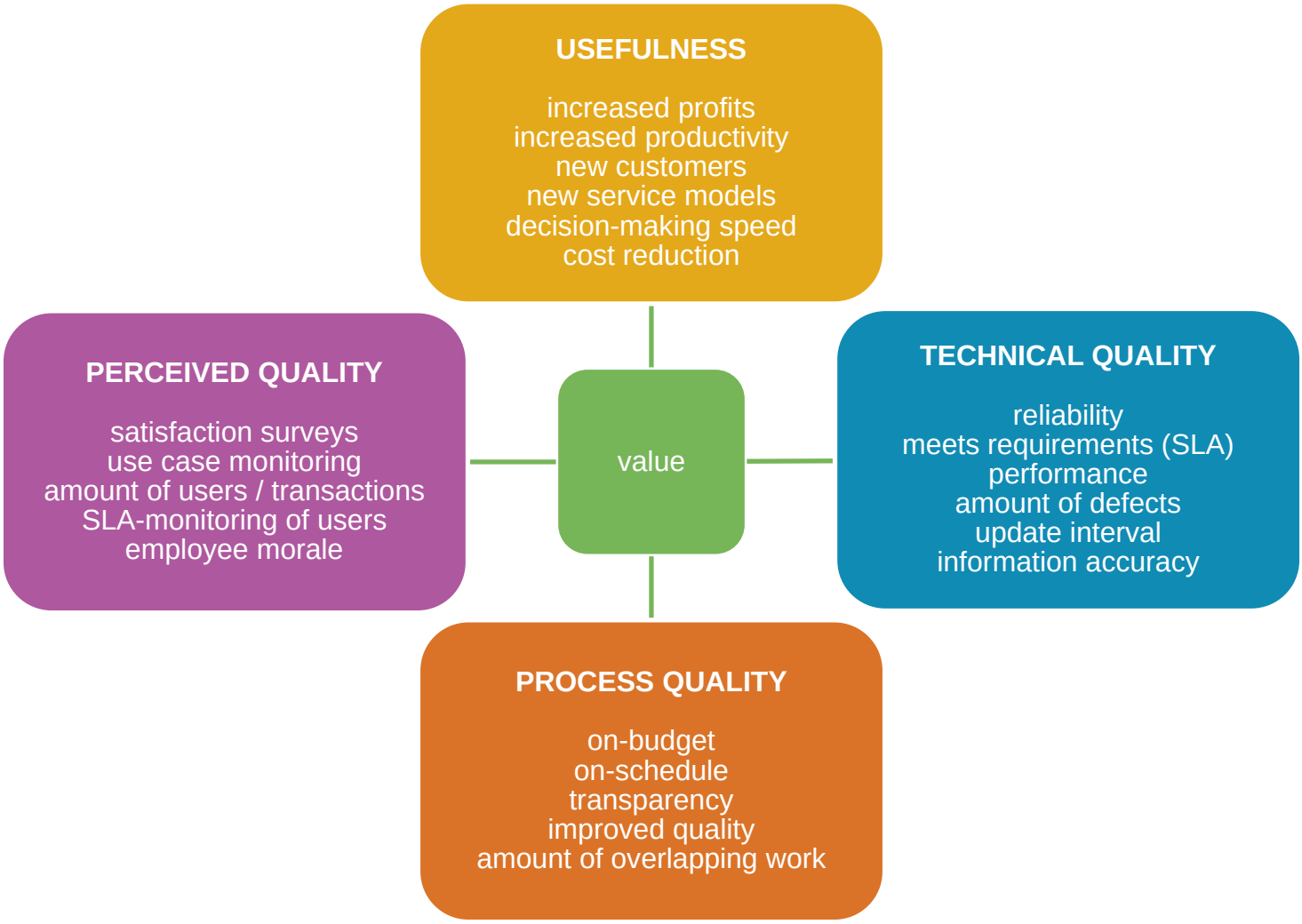
Class	Type of benefit
Productivity	Increase in productivity
Quality	Increase in quality attributes (e.g., reliability, usability, etc.)
	Reduction in defects
	Reduction in defect density
Cost	Reduction project cost
	Reduction product cost
	Reduction rework cost
	Reduction cost of quality
Schedule	Increase in schedule accuracy
	Increase of on-time delivery
	Reduction of throughput time (time-to-market)
Effort	Reduction of work effort
	Reduction of rework (cycles)
Customer	Increase of customer satisfaction
	Increase in sales revenues
	Increase in profitability
Staff	Increase in staff morale
	Decrease in over-time
	Decrease of staff turnover

TABLE X
DETAILED MEASUREMENTS FOR THE ROI CALCULATION OF CASE 1 [81]

Cost/Benefits	Value	Explanation
Cost		
Effort engineering team	$5,000	80 hours effort expenditure in measurement program related tasks, measured from hour registration system
Effort GQM team	$15,000	240 hours effort expenditure for measurement program, measured from hour registration system
Total cost	$20,000	
Benefits		
Effort saving due to less interrupts	$16,000	260 hours effort saving during the measurement program due to a measured reduction of interrupts
Effort saving reuse (GQM team)	$4,000	60 hours effort saving due to reusable material on interrupt reduction
Total direct benefits	$20,000	
Early delivery due to effort saving	$100,000	One week early delivery of the product, measured from value indicated by marketing manager
Effort saving due to spin-off	$50,000	Effort saving during remainder of the year due to the reduction of interrupts
Increased quality awareness	$100,000	Increased focus on quality and time expenditure, both in the project as in other groups, measured from value for group manager (combination of buy-in and personal value)
Update of engineering documentation	$16,000	Some documentation was updated due to a measurable number of interrupts on these documents, measured from value for engineers
Total indirect benefits	$266,000	
Total benefits	$286,000	
Return-on-Investment	1:13	

- What is your opinion of the following model that presents IS value through IS quality?

- Which of the metrics in the following model would be especially important in your company?



- Can I use your name in the Master's thesis?

Thank you for your time!