Evaluating the Engagement in Fashionable IT Innovations Considering Risk and Return

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“A Scout smiles and whistles under all circumstances.”

Sir Robert Baden-Powell, Founder of Scouting

Table of Contents

Please note: Pages are consecutively numbered per chapter and within chapter III per section, each representing one research paper. References are provided at the end of each chapter or each research paper, respectively.

Index of Research Papers

This dissertation contains the following research papers:

Research Paper 1:

Moser F. (2011) Evaluating IT Fashion Investments regarding Risk and Return. In: Proceedings of the 17th Americas Conference on Information Systems, Detroit, MI, USA, paper 207
(VHB-JOURQUAL 2.1: 5.92 points, category D)

Research Paper 2:

Häckel B., Isakovic I., Moser F. (2013) Integrated long- and short-term valuation of IT innovation investments. Resubmitted (Revise & Resubmit) to Electronic Markets – The International Journal on Networked Business
(VHB-JOURQUAL 2.1: 6.85 points, category C; Impact Factor 2012: 0.429)

Research Paper 3:

Fridgen G., Moser F. (2013) Using IT Fashion Investments to optimize an IT Innovation Portfolio's Risk and Return. Appears in: Journal of Decision Systems 22(4), 2013
(VHB-JOURQUAL 2.1: 7.17 points, category B, Impact Factor 2011: 0.213)

Research Paper 4:

Häckel B., Isakovic I., Moser F. (2013) The Error of Fixed Strategies in IT Innovation Investment Decisions. In: Proceedings of the 21st European Conference on Information Systems, Utrecht, The Netherlands, paper 158
(VHB-JOURQUAL 2.1: 7.37 points, category B)

Research Paper 5:

Mette P., Moser F., Fridgen G., (2013) A Quantitative Model for Using Open Innovation in Mobile Service Development. In: Proceedings of the 11th International Conference Wirtschaftsinformatik, Leipzig, Germany, paper 5
(VHB-JOURQUAL 2.1: 6.73 points, category C)

I Introduction

As during the 1950s, a technology, "[…] so new that its significance is still difficult to evaluate", began to take hold in companies, researchers predicted it to "[…] move into the managerial scene rapidly, with definite and far-reaching impact on managerial organization" (Leavitt & Whisler, 1958, p. 41). Since this promising technology lacked a single and broadly established name, the authors within their visionary work "Management in the 1980s" proposed to call it *"Information Technology (IT)"* (Leavitt & Whisler, 1958, p.41).[1] Ever since, the rapid development of technological progresses, particularly within the field of information, telecommunication and computer technology massively has heightened the strategic role and importance of new emerging IT as a driver of growth and sustainable advantage (A.T. Kearney, 2012; Porter & Millar, 1985; Zhu & Weyant, 2003).

In contrast to operational IT assets (existing infrastructure, software, or processes) which form a company's operational baseline and enable stable day-to-day business support (Maizlish & Handler, 2005), this dissertation's focus is on a company's portfolio of IT innovations, a topic which experiences increased attention in research and practice since the 1990s (Fichman, 2004). Though IT innovations are closely linked with conventional innovations, the emerging role and the idiosyncrasies of new IT in companies require a differentiation and own definition of IT innovations (Fichman, 1992; Swanson, 1994). Thus, researchers defined IT innovations as "[…] administrative or operational ideas, practices, or objects perceived as new by an organizational unit and whose underlying basis lies with information technology" (Lind & Zmud, 1991, p.196). Swanson (1994, p. 1072) understands IT innovations as innovations "[…] in the organizational application of digital computer and communications technologies (now commonly known as information technology)". Others like Lee and Kim (1998) or Lyytinen and Rose (2003) emphasize that IT innovations always base on the usage of information technologies and in their core always include a technological component like changes in hardware or software which are *new to a company*. Though a direct

[1] According to Schryen (2010) and the ATIS Telecom Glossary (2013), IT in our understanding can be defined as *the entire infrastructure, organization, and components to collect, store, manipulate, manage, move, control, display, switch, interchange, receipt, and process information as well as the development and use of hardware, software, firmware, and procedures associated with this processing.*

interrelationship between IT innovations and company growth is not guaranteed, it is generally accepted that IT innovations provide companies the possibility of easier market access, the potential to differentiate themselves through new products and services, or to enhance efficiency to reduce costs. This altogether contributes to higher profitability, market share and thus higher future cash flows (Lu & Ramamurthy, 2010; McAfee & Brynjolfsson, 2008; Wang, 2010). Considering this financial aspect as well as the relentless penetration of nearly every organizational aspect with IT and how the speed and the extent of innovative IT's emergence dramatically has increased, it is not surprising that for almost 90% of companies, IT innovations have become even more important during the last five years (A.T. Kearney, 2012). Topics like online social networks, mobility, cloud computing, the Internet of things, 3D printing or big data are just a few of nearly 2,000 topics, the current Gartner Hype Cycle of emerging technologies lists as promising IT innovations that companies in a digitalized world should bring on their innovation radar (Gartner, 2012). Though the dot-com bubble which was built on similar highly exaggerated expectations regarding the role of innovative IT dates back only about a decade, various companies again plan IT innovation investments up to hundreds of millions of US Dollars (Gartner, 2013).

Despite such high expectations regarding the role of IT innovations as value contributor, Stratopoulos and Lim (2010) emphasize that it is not the single investment in an IT innovation that leads to sustained competitive advantage or long-term maximization of company value. Instead, it is a company's ability to innovate mindfully with new emerging IT on the basis of a well-founded IT innovation (decision making) process that makes the difference (Stratopoulos & Lim, 2010; Swanson & Ramiller, 2004). According to Gallivan (2001) as well as Swanson and Ramiller (2004), innovating with IT is a process which includes the following phases: *comprehension*, *adoption*, *implementation* and *assimilation* as illustrated in Figure I-1.

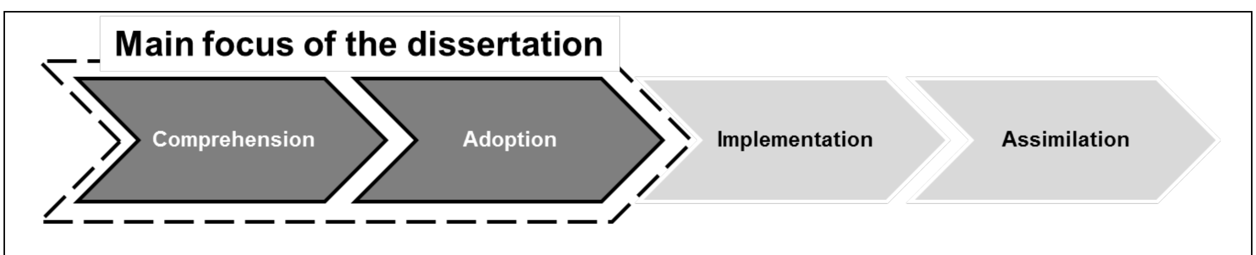

Figure I.1: The process of innovating with IT.

- *Comprehension phase:* A company has to learn about the IT innovation's intent and why an investment can make sense.
- *Adoption phase:* The IT innovation's purpose, its benefits, and technical features require a solid assessment. In this phase also the IT innovation's business case has to be evaluated.
- *Implementation phase:* The company has to identify its capabilities which are required to arrange the IT innovation in the company-specific context. Additionally, this requires employee's acceptance, training, and possibly technical and processual modifications of the IT innovation.
- *Assimilation phase:* The IT innovation has to be integrated into the daily business and has to be thoroughly understood to make it productive.

The focus of this dissertation's papers thereby lies on the comprehension and adoption phase in which a company needs to evaluate the financial investment (i.e., engagement) in a certain IT innovation.[1] Within these two phases, companies require well-founded methods for decision making on the basis of a thorough analysis which considers the company's organizational facts and specifics. In particular, the company within the early phase of the process needs to answer the central questions of ***whether, when, and to which extent to engage in new emerging IT innovations*** (Downs Jr & Mohr, 1976; Swanson, 1994; Swanson & Ramiller, 2004).

Though the question of *whether* on a first view might appear trivial as IT innovations generally are supposed to be beneficial, theory of mindfulness in IT innovation engagement emphasizes the thorough selection of appropriate types of IT innovations (Swanson & Ramiller, 2004). Thus, there might be reasons why companies should not engage in certain (types of) IT innovations.

When to engage in IT innovations is even more crucial given the fact that IT innovations usually do not appear from nowhere but undergo a lifecycle which is related to the concept of innovation diffusion (Rogers, 2003) and the "Hype Cycles" of the firm Gartner (Fenn & Raskino, 2008). These two concepts illustrate the start of an IT innovation's lifecycle from its initial emergence (in which only a small group of early

[2] We in the following use the terminology "engagement in IT innovations" as a company's activities within the first two phases of the IT innovation process.

innovators is engaged) via a peak of inflated expectations and a trough of disillusionment to its successful institutionalization and broad adoption by the majority of companies. Though previous literature emphasized that companies engage in the early phase of an IT innovation's lifecycle usually to realize first mover advantages and thus to improve later performance (Tolbert & Zucker, 1983), the theory of information technology fashions, in which this dissertation is embedded in, recently provided a novel explanation for the early engagement in IT innovations (Baskerville & Myers, 2009; Wang, 2010). According to this theory, companies in the early phase of an IT innovation's lifecycle often do not engage due to a well-founded decision process but rather on a gut feeling or bandwagon effect which is based on the "[…] transitory collective belief that an information technology is new, efficient, and at the forefront of practice." (Wang, 2010, p. 64). Literature showed that nearly every new emerging IT innovation undergoes such a phase in which the legitimacy stems from the hype around a technology, regardless of its actual development or utility (Baskerville & Myers, 2009). Thus, we in this dissertation define and understand IT innovations which undergo such a hyped phase as ***fashionable IT innovations***. The fact that companies often enough jump on the bandwagon rather than thoroughly evaluating an engagement in such fashionable IT innovations is demonstrated by the following example regarding Enterprise Resource Planning (ERP) which experienced its fashionable phase between 1997 and 1999 (Wang, 2010):

> *"By the mid-1990s, […] the ERP genie was out of the bottle – every company needed to have an ERP implementation […] When I asked (one client) why he was embarking on an ERP program, he looked at me in a puzzled way and said, "No one ever asked me that before." After 45 min of further discussion, he could still not come up with a reason"* (Keller, 1999, p. 45-46; quoted according to Swanson & Ramiller, 2004, p. 554).

One of the major arguments why companies should conduct high short-term investments and engage in such fashionable IT innovations which are far from maturity is the possibility of high returns due to competitive and first mover advantages in the long-run (Stratopoulos & Lim, 2010; Wang, 2010). However, a company also needs to consider the financial risk of finding itself stranded with an odd technology without further use in case the former hyped IT innovation does not become broadly accepted in the long-run. Other research in opposite emphasizes that companies also need to consider the risk of not engaging and thus being out-innovated by competitors (Ghemawat, 1993; Lu & Ramamurthy, 2010). As not every company is willing or able to consider and manage the potential of risk and return adequately, a balanced view in the decision making process often is neglected (Lu & Ramamurthy, 2010; Swanson & Ramiller, 2004; Wang, 2010).

In case a company decides to engage in fashionable IT innovations, the question *to which extent* an engagement is appropriate for the company's specifics and goals becomes relevant (Downs Jr & Mohr, 1976). Whereas some literature suggests to invest more or less fixed amounts in "IT experiments" (Ross & Beath, 2002) or "transformational innovations" (Nagji & Tuff, 2012), a mindful innovation strategy is characterized by a company specific decision making process (Swanson & Ramiller, 2004) rather than following such rule-of-thumb. In the end, companies on the basis of a well-founded analysis have to take a decision which might either lead to a non-engagement, an engagement on an experimental basis, or a substantial engagement with all the potential risk and return associated with.

To support mindful engagement in (fashionable) IT innovations, Baskerville and Myers (2009) suggest that IS research should participate more directly in the process and evaluation regarding fashionable IT innovations using research methods like design science which is one of the central research methods within this dissertation. As nearly 75% of existing IT innovation literature is based on surveys or case studies, Williams et al. (2009) in the same vein demand for more methodological variety within IT innovation research to avoid overall homogeneity and to broaden the research discipline's scope and utility for practice. Though existing IT fashion research as a subdomain of IT innovation research already provides valuable insights into the advantages of an engagement in fashionable IT innovations on the basis of empirical and qualitative work, it stays on a rather generic level and does not provide ex ante decision models that consider the idiosyncrasies of fashionable IT innovations.

However, when aiming at ex ante decision models regarding the engagement in fashionable IT innovations, various challenges occur. As an example, one is the high risk of an engagement in (fashionable) IT innovations due to the uncertainty about their long-term development which needs to be incorporated within the evaluation. Another is the fact that given the substantial short-term investments which are required for an engagement in a novel technology, there exists a time lag between the initial investment and highly uncertain long-term returns which needs to be addressed. Last, IT innovation research is a vivid domain which permanently is influenced and enriched by new methods or topics like Open Innovation which throw over dominant paradigms or approaches and require openness for new developments (Fichman, 2004; Steininger et al., 2009; Williams et al., 2009).

For that, this dissertation aims to contribute to the closure of this research gap and provides insights and starting points for research and practice. The following section I.1 illustrates the dissertation's objectives and structure. In the subsequent section I.2, the corresponding research papers are embedded in the research context and the fundamental research questions are highlighted.

I.1 Objectives and Structure of the Dissertation

The main objective of this dissertation is to contribute to the field of IT innovation management by particularly focusing on the engagement in fashionable IT innovations as an emerging phenomenon and widely discussed topic in research and practice. Figure I-2 provides an overview of the dissertation's pursued objectives and its structure.

I	Introduction
Objective I.1:	Outlining the objectives and the structure of the dissertation
Objective I.2:	Embedding the included research papers into the context of the dissertation and formulating the fundamental research questions
II	**The characteristics and evolution of fashionable IT innovations (Research Paper 1)**
Objective II.1:	Analyzing the major characteristics of fashionable IT innovations as well as their potential evolution and the outcome of different IT innovation strategies
Objective II.2:	Outlining the major factors that influence institutionalization and thus the risk and return potential of an engagement in fashionable IT innovations
Objective II.3	Discussing potential challenges for the evaluation of an engagement in fashionable IT innovations
III	**Evaluating the engagement in fashionable IT innovations considering risk and return (Research Papers 2, 3, and 4)**
Objective III.1:	Evaluating the general engagement in IT innovations by considering their long- and short-term impact, risks as well as interdependencies between IT innovation investments and the existing IT (innovation) portfolio
Objective III.2:	Outlining the advantageousness of an engagement in fashionable IT innovations for an IT innovation portfolio's risk and return by applying portfolio theory in a single-period scenario
Objective III.3:	Developing a novel approach that dynamically optimizes the engagement in fashionable IT innovations in a two-periods model
Objective III.4:	Demonstrating the valuation error that stems from applying fixed strategies regarding the engagement in fashionable IT innovations
IV	**Evaluating the engagement in Open Innovation for developing (fashionable) IT innovations (Research Paper 5)**
Objective IV.1:	Demonstrating Open Innovation as a suitable approach to develop successful IT innovations
Objective IV.2:	Analyzing the effect chain between Open Innovation and economic profit by putting special emphasis on the specifics of mobile services
V	**Conclusion and Outlook**
Objective V.1:	Summarizing the key findings
Objective V.2:	Identifying and highlighting areas for future research

Figure I.2: Objectives and structure of the dissertation.

I.2 Research Context and Research Questions

In the following section, the corresponding research papers included in this dissertation are embedded in the research context with respect to the above stated objectives and the respective research questions are motivated.

I.2.1 The characteristics and evolution of fashionable IT innovations

Research Paper 1*: “Evaluating IT Fashion Investments regarding Risk and Return”*

Though there exists a long list of new technologies like Wireless Access Point (WAP) or concepts like virtual worlds which could not fulfill the high expectations, companies still heavily invest in new emerging, but immature IT innovations (Fenn & Linden, 2005; Fenn & Raskino, 2008; Gartner, 2013). To examine why companies (should) engage in such technologies within a very early phase of diffusion, IT fashion research proposes to extend conventional IT innovation literature. On the basis of management fashion research, this literature argues that IT practices during the early and middle phase of broad diffusion follow fashion waves which often lead to bandwagon behavior rather than well-founded decision making (Fichman, 2004; Wang, 2010).

Whereas investing within this phase bears the risk of investing in immature technology, or even bankruptcy in case of non-institutionalization, investing (too) late bears the risk of being out-innovated by competitors and losing customers due to outdated technology and services (Stratopoulos & Lim, 2010). As both strategies have to be considered risky, the first research paper generally and qualitatively aims at contributing to a better understanding of the evolution of such fashionable IT innovations. It examines which characteristics of technologies probably influence or impede institutionalization and thus need to be considered for different IT innovation strategies regarding risk and return. Doing that, it addresses the following research questions which set the conceptual basis for the subsequent chapters:

- How do fashionable IT innovations emerge and what are possible paths of evolution?

- Why should companies consider both, risk and return when considering an engagement in a fashionable IT innovation?
- Which characteristics of a fashionable IT innovation can determine the risk and the return of an engagement and how?
- Which challenges occur within the evaluation of an engagement in fashionable IT innovations?

I.2.2 Evaluating the engagement in fashionable IT innovations considering risk and return

Research Paper 2*: “Integrated long- and short-term valuation of IT innovation investments”*

One of the major idiosyncrasies of (fashionable) IT innovations to distinguish them from normal IT investments is the novelty for a company. Depending on the novelty grade, IT innovations can be characterized as incremental (i.e., minor changes for existing IT infrastructure, business model or processes, routine changes) or radical (i.e., substantial impact, lack of experience, best practices etc.) (Betz, 2011; Garcia & Calantone, 2002; Miller & Miller, 2012). As more novelty usually comes along with a lack of best practices or company experience regarding the impact on the business model or business processes, an engagement in (fashionable) IT innovations often is characterized by a considerable time lag between the initial investment spending and the realization of a highly uncertain long-term value contribution. In addition, this novelty also brings substantially more complexity for existing routines, staff allocation, processes, and infrastructure within the existing IT portfolio (Maizlish & Handler, 2005; Santhanam & Kyparisis, 1996). In case resource conflicts regarding infrastructure or staff extensively impact other parts of the IT portfolio, existing routines or staff allocation, interdependencies between a (radical) IT innovation and the existing IT portfolio occur (Santhanam & Kyparisis, 1996). For mindfulness within the decision making on whether to engage in a fashionable IT innovation, research paper 2 thus aims at integrating both, the short- and long-term implications of IT innovation investments as well as their impact on the existing IT portfolio by focusing on the following research questions:

- How can IT innovations be distinguished from other IT investments?
- Why is the evaluation of an engagement in IT innovations on the basis of financial methods suitable to support value-based management?
- How can IT innovation investments be valuated to consider both, long- as well as short-term objectives of a company?
- How can IT innovation investments be evaluated by simultaneously considering risk as well as the interdependencies between the IT innovation investment and the existing IT portfolio?

Research Paper 3*: "Using IT Fashion Investments to optimize an IT Innovation Portfolio's Risk and Return"*

In contrast to the previous research paper which aims at determining the value contribution of a single IT innovation investment in an IT portfolio context, research paper 3 takes a more holistic view on the entire IT innovation portfolio. On the basis of financial theory where building a portfolio of several risky financial assets is widely accepted to outperform investments in one single risky asset, this research paper focuses on the high risk that is associated with fashionable IT innovations as a main idiosyncrasy. This high risk stems from i) the potential non-institutionalization (as described above and more in detail in research paper 1), ii) a lack of experience, best practices, and the rumor spread by a so called fashion-setting-network (e.g., consultants, academics) which make estimations about the real potential highly volatile and difficult, and iii) the fact that even in case the technology becomes institutionalized, the implementation of a fashionable IT innovation is more difficult than adopting a more mature technology. By considering this risk as well as interdependencies (as addressed in research paper 2) between fashionable IT innovations and other parts of the IT (innovation) portfolio, research paper 3 applies modern portfolio theory (Markowitz, 1952) and weights fashionable IT innovations and non-fashionable IT innovations in a single-period scenario. By doing that, the paper addresses the question of whether and to which extent an engagement in fashionable IT innovations can make sense for companies even if they might aim at a rather risk-averse innovation-laggard strategy (Lu & Ramamurthy, 2010; Stratopoulos & Lim, 2010). While transferring central findings and ideas of portfolio and decision theory to the research field of IT fashions and IT innovation, the following research questions are addressed:

- How can a rather risky engagement in fashionable IT innovations contribute to the minimization of an IT innovation portfolio's overall risk?
- How can an IT innovation portfolio's value be maximized by the engagement in fashionable IT innovations when considering risk *and* return?
- How do certain characteristics of fashionable IT innovations (high risk, high potential return, and interdependencies) and the decision maker (risk aversion) affect the optimal engagement in fashionable IT innovations from an IT innovation portfolio perspective?

Research Paper 4: *"The Error of Fixed Strategies in IT Innovation Investment Decisions"*

Though research paper 3 on the basis of modern portfolio theory in a single-period scenario showed the theoretically optimal allocation of an IT innovation portfolio to mature (i.e., non-fashionable) and fashionable IT innovations, management's uncertainty, missing data, gut feeling, or political reasons often lead to rule-of-thumb IT innovation investment strategies (Nagji & Tuff, 2012; Swanson & Ramiller, 2004). By blindly jumping on the bandwagon of fashionable IT innovations, decision makers often enough neglect the long-term implication of such an engagement (a topic also addressed in research paper 2). On the other side, companies are well-advised by considering the engagement in fashionable IT innovations not merely as a flash in the pan but as persistent part of their IT innovation strategy (Ross & Beath, 2002; Stratopoulos & Lim, 2010). However, even if companies consider the engagement in fashionable IT innovations within their IT innovation strategy, they often are uncertain whether a systematic innovator strategy (which permanently engages in fashionable IT innovations to constantly have the chance to realize first mover advantages) or an opportunistic adopter strategy (to stay on an experimental level which avoids substantial damage in case a technology gets stranded) is beneficial (Hoppe, 2000; Lu & Ramamurthy, 2010; Stratopoulos & Lim, 2010). To contribute to existing literature on whether, when and to which extent an engagement in fashionable IT innovations is beneficial and which IT innovation strategy is more promising, research paper 4 takes the results of the previous papers as a basis and by applying a two-period dynamic optimization model addresses the following research questions:

- What is the optimal engagement in fashionable IT innovations in a two-period scenario?
- How substantial is the potential error that results from applying rule-of-thumb strategies regarding the engagement in fashionable IT innovations?
- Which strategy (over- or underinvesting in fashionable IT innovations) is beneficial?
- The underinvestment in which type of IT innovation (mature IT innovation vs. fashionable IT innovation) can be considered as more risky for the company?

I.2.3 Evaluating the engagement in Open Innovation for developing (fashionable) IT innovations

Research Paper 5: "A Quantitative Model for Using Open Innovation in Mobile Service Development"

IT innovation literature constantly experiences discussions about new research streams, new emerging technologies to study and new concepts of how to apply innovation management in companies (Fichman, 2004; Steininger et al., 2009; Williams et al., 2009). Next to IT fashion research which emerged as a new research stream within the last decade, also new technologies and concepts experienced increased attention. One example of a technology that gained increased attention during the last decade is mobile technology which successfully evolved from being a fashionable IT innovation into a broadly institutionalized technology which forms the basis for various new business models and research (Herzhoff, 2010; Steininger et al., 2009). Looking at new innovation methods, one cannot neglect the success of Open

Innovation, a concept brought up by Chesbrough (2003) which relentlessly rushed into the attention of research and practice during the last decade (Schroll & Mild, 2012).

Open Innovation activities within the innovation management process regarding mobile service technologies can create substantial economic impact. However, the application of Open Innovation activities demand for high investments but lack a precise relation between the money invested and the generated economic value. Thus, research paper 5 analyzes the cause-and-effect chain between investments in Open Innovation activities and economic profit through mobile service technologies. By doing that, it addresses both, mobile technology as a former fashionable IT innovation and Open Innovation as a new established concept. Whereas the previous research papers approached IT innovations generally, research paper 5 emphasizes a particular IT innovation and innovation management concept and by addressing the following research questions so contributes to new IT innovation research approaches:

- How does Open Innovation affect the innovation management regarding mobile service technologies?
- What is the cause-and-effect chain between Open Innovation activities in mobile service technology innovation management and the economic profit generated by innovative mobile services?
- What is the optimal amount of investments in Open Innovation activities in mobile service innovation management?

After this introduction which aimed at outlining the objectives and the structure of the dissertation as well as motivating the research's context and formulating the fundamental research questions, the respective research papers are presented in chapters II, III and IV. Subsequently, chapter V summarizes the key findings and highlights areas for future research in the field of the engagement in fashionable IT innovations.

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II The characteristics and evolution of fashionable IT innovations (Research Paper 1: "Evaluating IT Fashion Investments regarding Risk and Return")

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Abstract:

IT fashions are IT innovations within a hyped phase. They are on the rise and claimed to be "the next big thing". Investing in IT fashions bears potential for high returns in case the technology becomes institutionalized and first mover advantages can be realized. Contrary, it bears the risk of investing in a losing technology. By waiting for others to make the first move organizations bypass this risk but accept the chance of being out-innovated. Depending on an emerging technology's evolution and its characteristics, the extent of risk and return differ for each strategy. Literature regarding risk and return of IT investments does not address these idiosyncrasies adequately. Our aim is to outline risk/return for each strategy and characteristics of emerging technologies that determine its extent. Hence, this conceptual paper brings together IT fashion and IT investment literature to provide a basis for further research on the evaluation of fashionable IT innovations.

II.1 Introduction

Due to the continuous and dynamic development of IT, increasing competition and expectations from customers, organizations regularly face the challenge to decide *whether*, *when* and in *which* new emerging IT innovation to invest. A central question thereby is whether an emerging IT innovation will become the "next big thing" with sustainable dominance or whether it is only a short-term hype that sooner or later fades away. To name a few examples buzzwords like Cloud Computing, Social Software Suites or (3D) Media Tablets are some topics that for now are extensively hyped both within research and practice (Gartner, 2010). Cloud Computing applications for example are predicted to grow by about 25% annually and will reach a volume of over 150 billion dollar in 2013 even though this concept neither is institutionalized nor seems to be within the next years (Pring et al., 2009). Nonetheless, Fujitsu, one of world's largest IT service providers will invest over one billion dollar, a quarter of Fujitus's annual capital spending, in Cloud Computing (DataCenter, 2010). Even though the list of new technologies not fulfilling its high expectations, the high failure rate of application service providers or the .com crisis should be enough warning, organizations still heavily invest in IT innovations within a fashionable phase (Fenn & Linden, 2005; Fenn & Raskino, 2008).

To emphasize the peculiarities of IT innovations within a fashionable phase literature agreed on a certain term for this type of IT innovation. In line with Wang (2010), Baskerville and Myers (2009), as well as Fichman (2004b), we define an *IT fashion* as an IT innovation that is going through a hyped phase, consequently is on the rise and by its proponents claimed to be a fundamental improvement. Hence, IT fashions are IT innovations during a fashionable phase (see also Wang (2010) for a methodological distinction between IT fashion and IT innovation).

Questions like how to evaluate or when and in which extent to invest in IT fashions are major challenges for organizations (Wang, 2010; Dos Santos & Peffers, 1995). Investing too early within a fashionable phase bears the risk of investing in immature technology leading to higher learning costs or even bankruptcy in the case the technology never becomes institutionalized. By investing (too) late organizations run the risk of being out-innovated by competitors and thus losing customers due to outdated technology and services, resulting in lower market share and returns (Stratopoulos & Lim, 2010). Nonetheless, organizations neglect a balanced view on risks and returns within the evaluation of fashionable IT innovations (Wang, 2010; Swanson & Ramiller, 2004; Fiol & O'Connor, 2003). As both strategies, investing rather early within a fashionable phase as well as investing rather late, have to be considered risky, existing literature dealing with the fashion phenomenon and the adoption of IT innovation emphasizes the importance of an integrated risk/return analysis of IT fashion investments (Wang 2010; Baskerville & Myers, 2009; Swanson & Ramiller, 2004; Wells et al., 2010).

The objective of this paper is to address and emphasize the extent of risk and return within the evaluation of IT fashion investments for both, an early investment as well as a late investment strategy. Drawing from related literature we furthermore identify seven characteristics of emerging technologies that determine the extent of risk and return for both strategies. Our aim is to bring together existing methodologies from IT investment literature with the idiosyncrasies of IT fashions and set the basis for further analytical research within this field to contribute to a central research question within IT innovation theory: *Whether*, *when* and in *which* new emerging IT innovation to invest.

II.2 Related Work

II.2.1 IT innovation research

The majority of IT innovation literature extensively examined the question which prerequisites organizations have to fulfill to adopt IT innovations early, with a certain frequency and a certain extent of implementation (Fichman, 2004b; Iacovou et al., 1995). It is widely accepted that a set of variables like size, structure, knowledge, or compatibility affects the quantity of IT innovation adoption within organizations and therefore can be described as an innovator profile. Organizations fitting this profile are expected to have higher expected returns by IT innovations as they can innovate easier and more effective. Next to these variables concerning the organization itself, other authors emphasize the probability of adoption and diffusion of a particular class of IT innovations according to their characteristics (Premkumar et al., 1994; Rai et al., 2009). Swanson and Ramiller (2004) as well as Fiol and O'Connor (2003) argue that organizations should regard the peculiarities of different types of IT innovations and stress the importance of a well-founded ex ante evaluation. In addition, Haner (2002) claims quality and a thorough selection of suitable types of (IT) innovations as an important determinant for positive returns through IT innovation investments. Fichman (2003) argues that an IT innovation's long-term destiny should be an important factor to incorporate within the evaluation of an IT innovation. By destiny he means that some IT innovations reach institutionalization whereas some are completely abandoned by organizations.

II.2.2 IT fashion research

While traditional IT innovation research is mainly focused on a phase in which an IT innovation already has been institutionalized, IT fashion research concentrates on the early hype and the middle phase of diffusion in which "[…] legitimacy stems from fashion, regardless of what the destiny of the innovation eventually turns out to be." (Wang, 2010, p.82). IT innovation literature hitherto stated that within the innovation lifecycle, early adoption of IT innovations is mainly driven by the need of performance improvements while the late adoption of IT innovations often is due to pursue legitimacy (Tolbert & Zucker, 1983). Though, IT fashion literature states that this theory is ambiguous to what happens in the very early and middle phase of diffusion and emphasizes the importance of this phase in which a technology has to cross the chasm from being a fashionable IT innovation into an institutionalized IT innovation and in which organizations and its stakeholders have to implement a relevant infrastructure (Moore, 2002). One might propose that in this setting usually the most efficient innovations that bring the most performance enhancement are going to become institutionalized. However, this proposition does not always hold true. First, each organization is unique and thereby realizes different performance enhancement from new emerging innovations. Second, innovations within the early and middle phase usually are object of fashion waves that vastly influence its popularity and therefore its broad acceptance and probability of becoming institutionalized (Wang, 2010). Hence, IT fashion research is derived from both, IT innovation and management fashion research (Baskerville & Myers, 2009; Abrahamson, 1991). Although both, management or administrative practices and IT practices follow fashion waves and have similar aspects, simply transferring the findings of management fashion theory on the IT field does not address the problem setting adequately (Wang, 2010). Certainly, some IT fashions may overlap with management fashions as well as IT fashions often enough show administrative aspects and vice versa, especially with the increasing role of IT within administrative techniques (Wang, 2010; Lee & Collar, 2003). Though, IT innovations in general and certainly IT fashions usually are characterized by software and/or hardware artifacts which are often tailored by a vendor for the organization which is engaged in the IT fashion. Consequently, investments in IT fashions often enough require high switching and investment costs that make a decision about an IT fashion different from a decision about a management fashion (Wang, 2010; Fichman, 2004b; Rogers, 2003). Hence, IT fashions have to be treated differently as management fashions and require different methods for evaluation and decision making. For the justification of a distinct IT fashion research, also Fichman (2003) and Wang (2010) distinguish management fashions from IT fashions. The uniqueness of certain IT innovations therefore requires separate IT fashion research to apply and extend management fashion theory as well as to develop a fashion theory specific for IT innovations (Wang, 2010). Walden and Browne (2009) focus on emerging technologies with high uncertainty that are adopted by a small group of technophile early adopters and find that following the behavior of similarly-situated organizations can be a useful strategy. This focus illustrates the decision making situation on IT fashion investments quite properly and the proposed strategy seems to be promising. Nevertheless, it still assumes the existence of first movers which – following the definition of IT fashions – often enough do not exist yet. Following other organizations in a community also assumes a constructive community learning process concerning innovations. Wang and Ramiller (2009) outline that IT fashions challenge this learning process as the discourse about a new emerging technology usually contains much more superstition and uncertainty about its future usefulness within its fashionable phase. Newell et al. (1998) as well as Westrup (2002) in this context examine the role of a “fashion setting network” of knowledge and idea entrepreneurs (academics, vendors, consultants, gurus etc.) that propagates an IT fashion as the basis of dramatic improvements. According to Swanson and Ramiller (2004, p.564) the justification of IT fashion investments thereby often is affected by a mindset of "[…] everyone is doing it […]" or "[…] it's time to catch up."

Little research has focused on the extent of risk and return concerning IT fashion investments. Wang (2010) examined that those organizations that invest in fashionable IT tend to have lower returns in the short-run but outperform their competitors in the long-run and thereby realize higher returns. However, focusing on returns neglects the fact that IT fashion investments can "[…] fail to produce expected benefits or indeed, any benefits at all." (Fichman 2004b, p.343). Hence, IT fashion investments have to be considered as very risky (Fenn & Raskino, 2008; Fichman, 2004b; Dos Santos & Peffers, 1995).

Further literature contributed concepts that exploit the similarities between IT fashion investments and investments in R&D (Schwartz & Zozaya-Gorostiza, 2003; McGrath 1997; Fichman, 2004a). Regarding investments in technological R&D, Cha et al. (2009) observed that service-oriented organizations are more likely to prioritize investments in R&D higher than non-service-oriented organizations. By exploiting the similarities from investments in technological R&D and new, immature and innovative technology, this investment type can be seen as platform for follow-up projects that builds upon the original investment. Hence, this approach supports the decision making process as a company can "[…] retain full exposure to the upside potential of the technology […]" but "[…] can limit losses to just the positioning investment if future events prove unfavorable." (Fichman, 2004a, p.134). Even though this seems promising for the evaluation of IT fashion investments regarding both, risk and return, investments in R&D are not entirely comparable to investments in IT fashions regarding two major aspects. First is that investments in R&D activities usually aim on fundamental research and therefore precede the very early phase of diffusion of an IT innovation meaning that the occurrence of an IT fashion usually follows R&D activities. Second is the fact that R&D activities usually are conducted by single organizations without integrating a network of stakeholders. Hence, a key characteristic regarding the evolution of IT fashions, the fashion-setting-network, is not applicable for investments in R&D. Investments in R&D activities therefore are different from investments in IT fashions where the focus is the engagement in an already existent technology or paradigm that is already developed but still lacks wide adoption and acceptance. Even though investments in IT fashions need to be treated differently, the methodologies are quite similar and therefore R&D evaluation methodologies are a promising direction for future research in the IT fashion area.

In what follows we go more into detail regarding this idiosyncrasy of IT fashion investments, analyze the role of risk return within the evaluation and emphasize the limits of existing IT investment evaluation approaches when applied to IT fashion investments.

II.3 IT fashion Investment Evaluation

II.3.1 From fashion to institutionalization

As IT fashion theory examines IT innovations within their fashionable phase, incorporating the fact that some technologies never become institutionalized and just remain a passing fad (=downside potential) should be a central and an important subject within the evaluation of IT fashion investments. The transition from IT fashion into an institutionalized technology is closely linked to the concept of "Hype Cycles", regularly published by Gartner (2010). This concept helps to illustrate the path of an IT fashion starting in a phase in which a *technology trigger* by a fashion setting network promotes it to be a technology that is "[…] new, efficient, and at the forefront of practice." (Wang, 2010, p.64). This hype usually ends up in a *peak of inflated expectations*. Sooner or later the hype fades away as the expectations of the benefits fall short of expectations, resulting in a *trough of disillusionment*. These three milestones mark the phase in which an IT innovation has fashionable aspects and in which a technology's destiny is unclear. Following this phase opportunistic adopters often enough abandon ship, rivaling and more mature technologies come up, shrinking IT budgets scale back IT projects and the IT innovation, former in fashion, now is out of fashion and gets stranded (Case I) (Wang, 2010; Stratopoulos & Lim, 2010). Only few technologies are worth to continue experimenting with and put solid hard work in to understand the technology's applicability, its risks and its benefits. In this case, this leads to a *slope of enlightenment* for the technology that is usually followed by a *plateau of productivity* in which the real world benefits are realized and the

IT innovation has evolved from an IT fashion into an institutionalized technology (Case II) (Fenn & Raskino, 2008; Stratopoulos & Lim, 2010). Figure II.1 illustrates the benefits/losses, organizations anticipate with a new emerging technology both within the hyped phase as well as for the scenarios of institutionalization and the possibility of investing in a technology that gets stranded.

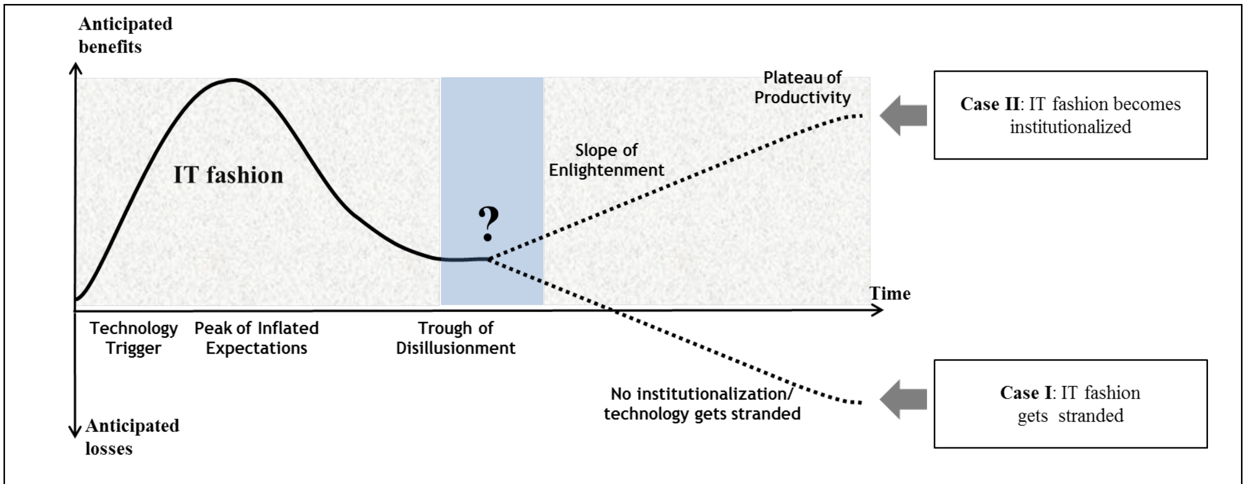

Figure II.1: An emerging technology's potential evolution.

II.3.2 Risk and return of early vs. late investments in IT fashions

In case the technology becomes institutionalized early adopters that invested within the fashionable phase can realize over-proportional higher returns in comparison to late investors due to first mover advantages (Wang, 2010; Kessler & Chakrabarti, 1996). On the other side, a late investment strategy saves costs and expenses in case the technology never becomes institutionalized as companies then can draw back on alternatives that have prevailed (Dos Santos & Peffers, 1995). Next to the returns, risk has to be considered: The investment in an IT fashion that never transforms into an institutionalized IT innovation bears the risk of losses or even bankruptcy (due to high development costs, useless and odd technology etc.) as investments in IT innovations often enough come along with "[…] broad process an strategy changes and large system developments that may take years to implement." (Fenn & Raskino, 2008, p.52). Hence, IT fashion investments are associated with high expected returns that come along with a high volatility and therefore are very risky. On the other side, a late adoption strategy that bypasses the risk of being stuck with a stranded technology by awaiting experiences of competitors has beneficial aspects (lower implementation costs due to existing routines, best practices, learning effects etc.). However, waiting for others to make the first move bears the risk of being out-innovated by early investors. In case the former fashionable technology will prevail, the risk of being out-innovated and thereby losing customers has to be considered. Consequently, expected returns of this strategy a) probably will not reach the level a first mover can realize and b) can heavily deviate downwards (=late mover disadvantage). Thus, a late investment strategy can hedge the over proportional high risk of investing in a stranded technology but simultaneously has to accept the possibility of losing a leadership position or even the threat of risking the organization's long-term competitiveness and survival. Figure II.2 illustrates possible scenarios for benefits/losses, organizations should anticipate for an early as well as for a late investment strategy and thereby shows the extent of risk which is illustrated by the high volatility, the return for each strategy and both cases (institutionalization vs. stranding of new emerging technology) shows. One could argue that measuring the upside potential as a risk is not intuitive. Measuring risk as volatility indeed is a concept that has its origins in financial and decision theory where the risk of a decision alternative is measured in terms of the variance, the possible outcome is associated with. Managerial theory and some IT investment research contrary often states that decision makers have a different conceptualization of risk as they usually judge losses more as a risk than potential gains (March & Shapira, 1987; Tanriverdi & Ruefli, 2004). Regarding the idiosyncrasies of evaluations of IT fashions, applying two sided risk measures in fact is useful as we regard an ex ante investment evaluation situation in which financial theory assumes a positive relationship between risk and return. Thus, the IT fashion at the time of investment bears both the chance of becoming institutionalized (upside "risk") and the possibility of ending as a losing technology (downside risk). An ex ante decision support model thereby aims on both, sanctioning the underestimation of investing in a losing technology as well as sanctioning the underestimation of the upside potential which can result in not being prepared adequately for the success (lack of capacity, service level agreements, client counselors etc.). Other literature that focuses on the risk/return relationship of IT investments (Dewan et al., 2007; Fogelström et al., 2010; Schwartz & Zozaya-Gorostiza, 2003) supports the use of two-sided risk measures and states that "[…]

IT investments can result in a range of positive or negative incremental cash flows […]" and thereby IT risk should be defined as "[…] the variability of returns […]" (Dewan et al., 2007, p.134).

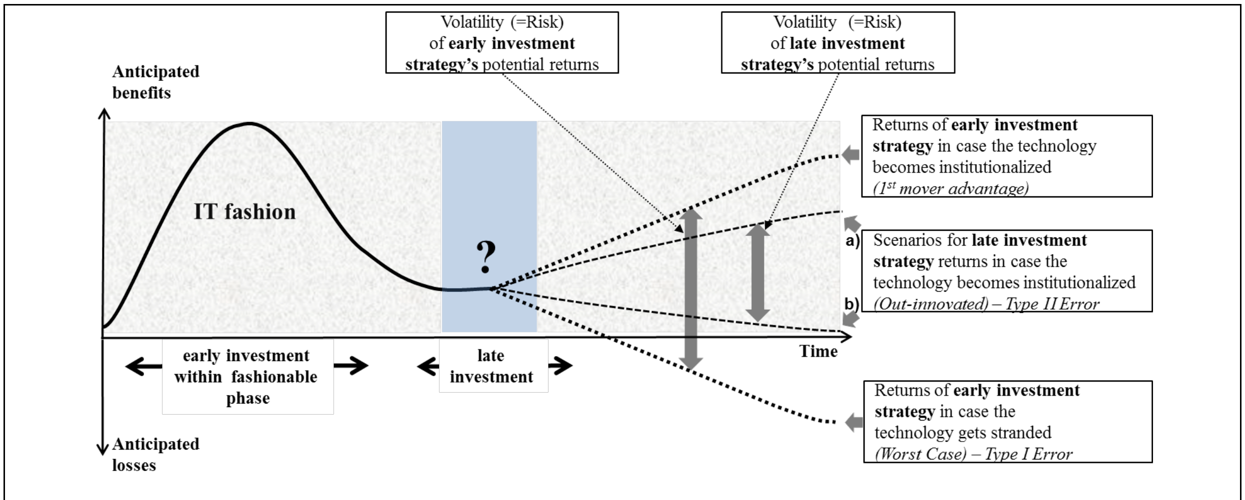

Figure II.2: Associated risk/return of late vs. early investment strategy.

II.3.3 Challenges for evaluation

The illustrated idiosyncrasies challenge most established qualitative and quantitative IT investment evaluation methods. The application of traditional financial or qualitative methods seems insufficient and misleads organizations within their decision making process on investments in emerging technologies. Traditional financial appraisal methods like Cost-Benefit-Ratio (CBR), Internal Rate of Return (IRR), Net Present Value (NPV) or advancements of these methods do not adequately consider the downside risk of investing in a technology that gets stranded. Applying real option approaches allows for uncertainty of future returns and flexibility to suspend or abandon an investment in a fashionable IT innovation in case it seems to remain just a transient fad. Still, they do not provide a decision on whether an early investment or a late investment strategy seems more promising as its application on IT fashions at first assumes the investment in an IT fashion and then enables a decision on whether to stick on the technology or not. Decision trees seem to be worthwhile but require solid estimations on the probability that an IT fashion becomes the next big thing. Portfolio approaches that aim on investing in several technologies simultaneously face a similar problem. In addition, their application is difficult as companies often cannot apply several emerging technologies simultaneously that require similar infrastructure. Additionally, investing too little in too many IT fashions still can be risky: An organization could end up in a situation in which it indeed is not out-innovated by competitors or is committed to a technology that gets stranded. Still it cannot fully realize competitive advantage as it is not committed enough to one technology and thereby forfeits reliability. Reliable estimations constitute an exception and managers that foresee what the next big thing is usually "[…] become rich, and may end up on the cover of business magazines." (Denrell & Fang, 2010, p.1653). The application of more strategic approaches like Critical Success Factors (CSF) or Multi-Objective/Multi-Criteria (MOMC) enables the definition of qualitative factors that are regarded as important by an organization. Still, this evaluation methodology suffers from the threat of biased decision makers that are misguided by a fashion setting network that enforces the fashionable status of an emerging technology. In addition, a quantitative evaluation that allows for an integrated risk/return evaluation to compare different alternatives is not provided by these strategic oriented methodologies. Hence, a poor application of existing methodologies misleads decision makers and therefore misguides organizations within their decision on whether and when to invest in fashionable IT.

Consequently, decision makers have to consider the extent of risk and return for an early as well as for a late investment strategy adequately. In addition to the uncertainty of a technology's evolution, both strategies' risk/return also depends on a technology's characteristics that determine the extent of risk and return for each strategy. By focusing on the impact on risk and return of the relevant characteristics, we set the basis for future empirical research as well as for analytical research that approaches investments in IT fashions with methods from financial or decision theory. Contrary to financial theory, IT investment literature assumes an ex ante non-linear relationship between risk and return of IT investments (Tanriverdi & Ruefli, 2004). Hence, we hereby provide the basis for future research that deals with the risk/return relationship by analyzing whether an IT fashion investment might contribute over- or under proportional risk for its return or whether the risk and return contribution might be balanced. Incorporating the risk/return contribution of IT fashion investments will be a crucial task for future decision models within this area. Decomposing the overall risk/return contribution of an IT fashion investment into its characteristics thereby is one key contribution of this paper. The seven characteristics that are analyzed in the following are derived from i) the discussion about the idiosyncrasies of IT fashions within this paper and ii) a thorough analysis of previous literature in IT fashion and IT innovation theory (Wang, 2010; Fichman, 2004b; Swanson & Ramiller, 2004; Rogers, 2003; Fichman, 2004a). We thereby analyzed the relevant literature, applied a similar approach as Fichman (2004a) and for this research concentrated on three complementary perspectives of IT innovation theory namely i) technology strategy, ii) innovative bandwagons and iii) technology adaptation. We consider the identified characteristics to be the most relevant for an integrated risk/return evaluation of fashionable technologies and the question of whether to invest within a fashionable phase or wait for institutionalization. As this paper aims on the technological dimension of fashionable IT innovations, we do not consider characteristics of organizations yet. Analyzing organizational aspects similar to an innovators profile will be focus of future research within the field of IT fashions. Our proposal of characteristics does not claim for completeness. Interdependencies in between the characteristics also could enhance, relax or supersede one or more characteristics. In what follows, we present those characteristics and analyze their implication on the extent of risk and return for both investment strategies given the uncertainty of the technology's evolution. Hence, this conceptual paper serves as a basis to extend existing evaluation methods or develop new methods that incorporate these characteristics that determine risk and return within the evaluation of fashionable IT investments as it seems "[…] important to consider what characteristics potential adopters evaluate in a technology." (Walden & Browne, 2009, p.57). Some characteristics thereby might illustrate the idiosyncrasies of IT fashion investments more adequate than others or are more exclusive relevant for IT fashion investments in opposite to other, non-fashionable IT innovations. To give a first idea of which characteristics (in our view) might be more or less appropriate, we ordered the characteristics according their ability to illustrate the peculiarities of IT fashion investments by starting with the most relevant and most appropriate.

II.3.4 Characteristics of emerging technologies that determine the extent of risk and return

Susceptibility to promotion by fashion setting network

Emerging technologies do not come into fashion accidentally. According to management and IT fashion theory fashion setting networks usually boost the hype that comes along with an emerging technology by producing discourse on the technology within books, articles, workshops or conferences (Wang, 2010; Abrahamson, 1991). On the one hand, the more an emerging technology is part of a fashion setting movement, the more likely it is that the fashion setting network drives it to institutionalization as parts of the network usually benefit from an institutionalization. On the other hand, the more an emerging technology is susceptible to activities and discourse within the fashion setting network, the more probable it is that opportunistic adopters jump on it but abandon ship later on, resulting in a higher risk concerning its destiny (Fichman, 2004a). Hence, a technology's susceptibility to a promotion by a fashion setting network has to be taken into consideration as a determent of risk and return within the evaluation to determine its scope of risk and return adequately. To incorporate this characteristic into an evaluation methodology, a measure for susceptibility has to be defined. This does not seem trivial but using the extent to which an IT fashion is promoted via different channels (online, conferences, white papers, workshops, academic research etc.) might serve as first step.

Prospective sustainability of competitive advantage

The competitive advantage resulting from an investment in an IT fashion that later on evolves to an institutionalized IT innovation (e.g. vendor lock-in effects) also depends on the easiness for competitors to copy and paste this success by investing later (Mata et al., 1995). The more difficult it is to copy the success when the technology is institutionalized, the higher the expected return for an early investor in case the IT fashion becomes institutionalized. Though this chance of higher expected returns in certain situations could easier justify the risk of an early investment there remains the risk that competitors can copy the technology faster than expected – leading to a higher volatility (=risk) of the higher expected returns. When evaluating IT fashion investments, the prospective sustainability of competitive advantage and its impact on the risk and return structure therefore has to be considered. As measuring the prospective sustainability of competitive advantage seems to be a challenging task, identifying measures for this characteristic still is subject to future research. In a first step, simulating possible scenarios might serve as a first step.

Prospective dominance

The higher the probability of investing in a technology that, once successfully institutionalized, will dominate the market (resulting in higher expected returns), the more worth it seems to run the risk that the technology gets stranded and the company backs on a losing technology (Fichman, 2004a). The extent to which an emerging technology will reach a dominant position once it has become institutionalized therefore is an important determent of risk and return that is to consider within the evaluation of an IT fashion. Similar to the before mentioned characteristic, estimating the prospective dominance seems to be challenging, requires further research and in the meanwhile needs simulating different scenarios to overcome the lack of adequate data for.

Radicalness

Radicalness of an emerging technology can be defined as its potential to reduce costs of production or to realize new business cases, resulting in higher returns. Radicalness thereby usually is connected with the extent the emerging technology changes existing processes, routines and infrastructure technology. Consequently, investing in a radical changing technology can lead to higher returns in case it becomes institutionalized at it is more difficult and takes longer for competitors to copy the technology etc. In case the technology gets stranded, radicalness increases the risk of bankruptcy etc. as the related changes within the organization cannot easily be changed back (Henderson & Clark, 1990). When evaluating IT fashion investments, the scope of radicalness of the emerging technology to evaluate should be considered adequately. As organizations have to analyze thoroughly possible changes regarding existing processes, routines and infrastructure technology when it aims on investing in IT fashions, the ex ante estimate of the IT fashion's radicalness should not be too difficult to implement.

Importance for business model

Whereas some emerging technologies are more critical for the business model of an organization and thereby contribute more to its value creation, some only have a supportive character (Porter, 2001). In case the technology evolves from an IT fashion into an institutionalized IT innovation, the investment in a hyped technology with high importance for the business model bears the potential for high returns. This is due to the fact that the first mover advantage is combined with the relevance of the technology for the business model. As a result, this significantly leads to a higher market share, more profits etc. (Kessler & Chakrabarti, 1996). In contrast, the investment in an IT fashion that has a high relevance for the business model bears the even higher risk of bankruptcy due to inappropriate technology and services in case the technology gets stranded. As the importance of an emerging technology for the business model influences both, risk and return, an evaluation method has to consider this characteristic adequately. Determining the importance of a fashionable technology for an organization’s business model is rather a simple task and therefore might be easy to measure and quantify.

Flexibility

Flexibility, meaning the range of possibilities of configurations, interactions with existing technologies or the possibility to adopt or abandon it sooner or later increases the possibility to use a fashionable technology in a different manner in case it does not become institutionalized. Therefore, the less flexible a technology is, the more risky the investment within its fashionable status has to be considered. Contrary, low flexibility makes it more difficult for competitors to copy and paste the technology or use it differently – making higher expected returns possible (Fichman, 2004a). In case an organization invests in a technology that does not become institutionalized, learning effects can ease the switch to related technologies that became accepted instead if the technology is flexible enough. As both, risk and return are determined by flexibility it should be considered adequately within the evaluation of IT fashion investments. Due to the fact that organizations carefully analyze new technology and the fit with their existing IT infrastructure, measuring flexibility of an IT fashion and incorporate it into an evaluation method seems rather easy to implement.

Divisibility

High divisibility, i.e. the option to divide the implementation of an emerging technology in several sequential stages whereas each already generates a positive payoff (Leonard-Barton, 1988) provides the opportunity to realize returns from an investment in an IT fashion even if it does not become institutionalized. This is an important issue to consider within the decision making process and evaluation of an IT fashion investment as it reduces the risk of being stuck with odd-technology without any possibility for value creation in case the technology does not become institutionalized. An IT fashion evaluation method therefore should consider divisibility as a determent of risk and return separately to enable an adequate evaluation. Similar to the before mentioned characteristic, determining and measuring the grade of divisibility and possible financial outcome of every sequential stage seems to be possible and therefore easy to implement within an evaluation method.

Figure II.3 summarizes the characteristics that determine the extent of risk and return, an IT fashion investment evaluation method should consider adequately. Next to the consideration of whether the emerging technology becomes institutionalized at all, these are determents of both strategies' (early vs. late investment) and both cases' (institutionalization vs. getting stranded) extent of risk and return. Hence, we propose to consider these determents within an adequate ex ante evaluation of IT fashion investments.

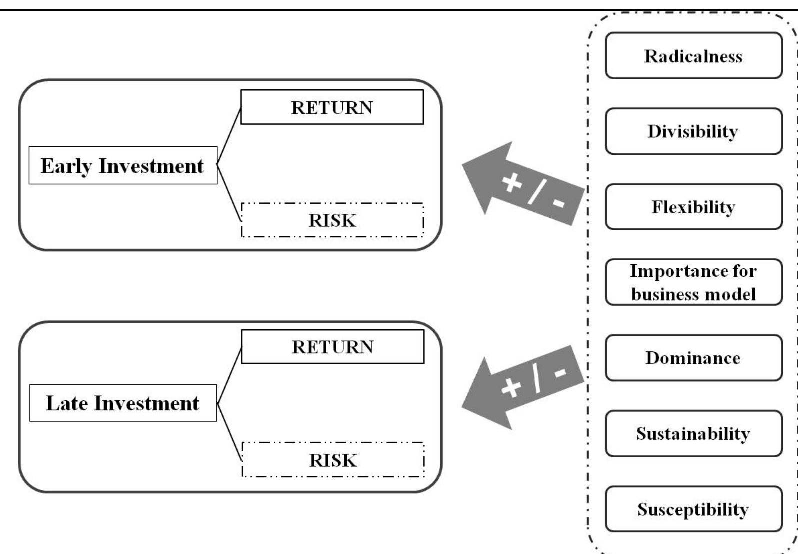

Figure II.3: Characteristics of emerging technologies that determine risk and return.

II.4 Conclusion and Implications for Future Research

Organizations face the challenge on whether to invest in IT innovations within a fashionable status (=IT fashion) and thereby follow an early bird strategy or whether to wait until the technology has become institutionalized. To provide a theoretical concept for further analytical ex ante and integrated risk/return evaluation models we examine the extent of risk/return within IT fashion investments for both strategies. Further, we identify and analyze relevant determents of risk and return that are to consider within an adequate evaluation of fashionable IT innovations. Analytical decision models that consider the presented and discussed determents within an integrated risk/return evaluation of IT fashion investments can provide valuable tools for the decision making process on the optimal point of time concerning the adoption of emerging technologies. By extending existing IT investment evaluation methods these models have to incorporate the idiosyncrasies of IT fashions adequately.

Certainly, evaluation methods that build upon our results will not able to predict the next big thing for sure. Also the list of characteristics we identified is derived argumentatively, may not be complete or needs empirical evidence. The derived and presented characteristic also cannot model all challenges of an early/late investment decision but provide a first basis. Further research herein needs to test these characteristics and their practical relevance. Equally there seem to be interdependencies in between the determents that are to consider within a decision model to consider the effects adequately. Also considering all determents simultaneously seems to be a challenging task. Incorporating all determents presented in this paper within one valuation approach seems very challenging, too. We therefore suggest incorporating those characteristics that seem to be the most important for a certain technology and/or organization.

The utilization of the basic findings presented within this paper and the application in an analytical ex ante decision model indeed seems to be a promising approach to support the questions of a) whether to invest in fashionable IT innovations, and b) which emerging IT innovation is more likely to become institutionalized, what the related risks are and whether it is worth to take these risks. The concept illustrated within this paper has two central implications for research and practice. Regarding the domain of IT fashion and IT innovation literature, the paper could guide future empirical and analytical research investigating the described characteristics and their impact on risk and return for an early as well as for a late investment strategy. For practitioners, the paper provides an overview of i) the risk/return structure regarding early and late investment strategies concerning IT fashion investments and ii) characteristics of IT fashions whose peculiarities might deserve to be considered within the valuation process.

An integrated view on both, risks and returns of IT fashions thereby can contribute to a central research question in IT innovation theory: *When to adopt an emerging IT innovation*. To answer these and further research questions on the engagement in IT fashion, the presented paper serves as a basis within IT fashion and IT innovation research and therefore contributes to the understanding and improvement of this research stream.

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III Evaluating the engagement in fashionable IT innovations considering risk and return

As outlined by chapter II on a conceptual basis, the engagement in fashionable IT innovations comes along with a high risk but also bear the chance of high return. However, to support the ex ante decision making, companies next to the conceptual knowledge of how different strategies can evolve need methods to evaluate an engagement. To provide such methods, chapter III proposes different approaches which aim at ex ante decision making on whether, when, and to which extent an engagement in fashionable IT innovations is beneficial and simultaneously address the question which IT innovation strategy (opportunistic adopter vs. systematic innovator) can be considered as advantageous regarding fashionable IT innovations.

The first research paper *"Integrated long- and short term valuation of IT innovation investments"* in section III.1 investigates how the short- and long-term implications of IT innovation investments generally can be integrated in the decision of whether to invest in a new emerging technology by simultaneously considering both, the high risk as well as the impact on the existing IT portfolio.

The second research paper *"Using IT Fashion Investments to optimize an IT Innovation Portfolio's Risk and Return"* in section III.2 illustrates why the engagement in high risk technologies like fashionable IT innovations is beneficial from an IT innovation portfolio perspective as they can maximize an IT innovation portfolio's value or even minimize the IT innovation portfolio's risk.

The third research paper "*The Error of Fixed Strategies in IT Innovation Investment Decisions"* in section III.3 determines the optimal allocation of an IT innovation budget to either fashionable or mature (i.e., non-fashionable) IT innovations and furthermore examines the damage which can occur from rule-of-thumb IT innovation strategies.

III.1 Research Paper 2: "Integrated long- and short-term valuation of IT innovation investments"

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Abstract:

The growing need for innovating with IT requires well-founded analysis of IT innovation investments. However, the time lag between IT innovation investments spending and the realization of a long-term value contribution challenges companies within the valuation of IT innovations due to a conflict between short-term corporate management and the aim of maximizing the long-term company value. In addition, high uncertainty about the outcome, complexity and missing experience makes IT innovation investments very risky. Depending on the radicalness and thus the existing internal experience or best practices, investments in IT innovations can account for substantial interdependencies with investments regarding hardware, software or human resources from an existing IT portfolio or other IT infrastructure. Next to the impact on the IT department, nearly every business unit in a company is affected by investments in IT innovations or requires investments in IT innovations to enhance its business processes, products, or services. This paper proposes an integrated long- and short-term valuation approach that in-corporates an IT innovation investment's effect on the *value of the company's IT portfolio both in the long as well as in the short run. Thereby, the proposed approach simultaneously accounts for risks and interdependencies. The approach is analyzed via sensitivity analysis to provide recommendations for research and practice.*

III.1.1 Introduction

In recent years, companies of almost all industries invest in innovative IT to gain and sustain long-term competitive advantage. Whereas *normal* IT investments like the replacement of a server or the update of the company's operating system barely impact the business model or business processes, IT innovation investments often mean adoption of an emerging technology or service which complement existing infrastructure and processes. Thus, IT innovation investments often come along with changes in hardware or software which are new to the company (Lyytinen & Rose, 2003). Depending on the grade of an IT innovation's novelty, the existence of best practices or experience as well as the impact on the business model or business processes, IT innovations can be characterized as incremental (i.e., minor changes for existing IT infrastructure, business model or processes, routine changes) or radical (i.e., substantial impact, lack of experience, best practices etc.) (Betz, 2011; Garcia & Calantone, 2002; Miller & Miller, 2012). The high novelty of radical IT innovations also often leads to a considerable time lag between initial investment spending and the realization of a highly uncertainty long-term value contribution. This is reasoned by a lack of experience from previous investments what requires more initial effort, thus impedes productive short-term usage by simultaneously making predictions about the long-term impact's extent rather difficult (Brynjolfsson & Hitt, 1996; Kivijärvi & Saarinen, 1995; Wang, 2010). Consequently, a premature investment in rather radical IT innovations with short-term cash-intensive changes that heavily affects business processes, strategy, or IT infrastructure can be a major threat for companies (Fenn & Raskino, 2008). As a consequence, most companies often concentrate on incremental IT innovations that allow for performance improvements and cost reductions in the short run or even neglect IT innovation investments generally due to internal or external pressure, short-term reporting requirements or budgetary restrictions (Robert & Sikes, 2010). Though most companies as well as research are basically aware of the importance of IT innovations to gain long-term competitive advantage (Lim & Stratopoulos, 2008; Stratopoulos & Lim, 2010), the latency between investment spending and value creation increasingly struggles companies to combine necessary short-term profitability and long-term growth through IT investments (Ross & Beath, 2002). To accomplish these - in parts conflicting - objectives, IT innovation investment decisions better need to trade off the short- and long-term impact within one valuation approach. Theoretically appreciating this necessity, there is, however, a lack of adequate methods for an integrated long- and short-term valuation in research as well as in practice. Thus, to contribute to the closure of this research gap, our first research question is the following:

RQ 1. How can IT innovation investments be valuated to consider both, long- as well as short-term objectives?

In addition to the risk risks of delays or difficult project implementation (Dewan et al., 2007; Maizlish & Handler, 2005) which are associated with almost every IT investments, the novelty of a (radical) IT innovation leads to a lack of best practices, as well as more complexity for existing routines, staff allocation, processes, and infrastructure within the existing IT portfolio's (Maizlish & Handler, 2005; Santhanam & Kyparisis, 1996). This often is linked with substantial challenges regarding user acceptance, compatibility and the uncertainty regarding their possible outcome (Dewan et al., 2007; Weill & Broadbent, 1998). All this leads to interdependencies between a (radical) IT innovation and the existing IT portfolio (i.e., structural or intratemporal interdependencies which occur at the same time) (Santhanam & Kyparisis, 1996). These occur when exemplarily resource conflicts regarding infrastructure or staff extensively impact other parts of the IT portfolio, existing routines or staff allocation regarding senior project managers etc. These interdependencies which are a distinctive characteristic of IT innovations require a differentiation compared to normal IT investments as they substantially can affect the IT portfolio's cash flows negatively and positively. Thus, the consideration of both, risk and interdependencies should be the core of each IT innovation investment valuation method. We take these two important characteristics of IT innovation investments within the integrated long- and short-term valuation and state our second research question:

RQ 2. How can IT innovation investments be evaluated by simultaneously considering risk as well as the interdependencies between the IT innovation investment and the existing IT portfolio?

The remainder of the paper is organized as follows: In III.1.2, we provide an overview on our research methodology, state the problem context and review existing literature streams relevant to IT (innovation) investment and IT portfolio management valuation. In III.1.3, we propose the valuation approach, whereas, in III.1.4, we analyze the approach's results via sensitivity analysis in the context of an application example to provide recommendations for research and practice. Finally, in III.1.5, the paper concludes by summarizing the key findings, discussing strengths and limitations as well as by pointing out topics for further research.

III.1.2 Problem Context and Related Work

In the following, we bring together central findings from IT innovation literature to motivate the importance of a long- and short-term integrated valuation of IT innovation investments. Additionally, we analyze the link to IT portfolio management to argue why the evaluation of IT innovation investments needs to be integrated in a portfolio context.

Research methodology and process

In accordance with the design-science research guidelines by (Gregor & Hevner, 2013; Hevner et al. 2004) we in the following develop our artifact, a model for the integrated long- and short-term valuation of IT innovation investments. According to Hevner et al. (2004), mathematical models are a common approach to represent an artifact in a structured and formalized way. For the evaluation, we in a second step combine a descriptive evaluation method (application example) with sensitivity analyses, an analytical method which is widely accepted in decision-making literature for evaluating artifacts based on mathematical models (Hevner et al., 2004; Pannell, 1997; Saltelli et al., 2008). For our literature review, we considered literature from IT portfolio management, IT investment, IT innovation, organizational innovation, and (financial) decision-making literature.

IT innovation investments vs. normal IT investments

Though naturally any type of innovation in a company leads to organizational changes (Lee & Kim, 1998), several authors emphasize the importance of dealing with the specifics of IT related innovations (Fichman, 1992; Swanson, 1994). To distinguish

IT innovation investments from normal IT investments, literature suggests different definitions. Whereas Swanson (1994) defines IT innovations as "[…] innovations in the organizational application of digital computer and communications technologies (now commonly known as information technology)", Linden and Zmud (1991, p.196) propose IT innovations to be "[…] administrative or operational ideas, practices, or objects perceived as new by an organizational unit and whose underlying basis lies with information technology". Lee and Kim (1998, p.263) emphasize that an IT innovation "[...] is always based on the use of information technologies and promotes subsequent managerial innovations in the organization.". Hence, IT innovations in their core always include a technological component like changes in hardware or software which are *new to a company and thus need to be treated differently* (Lyytinen & Rose, 2003). This novelty which can bring extensive impact on a company's IT infrastructure, business processes, the business model, or even a whole industry, can be characterized as incremental or radical (Betz, 2011; Garcia & Calantone, 2002; Miller & Miller, 2012). Thus, the more radical an IT innovation is, the higher the difference to a normal IT investment where companies usually can draw on best practices and external experience which reduces uncertainty and complexity. In contrast to normal IT investments, such radical IT innovations often enough complement the existing IT or business model as they allow for complete new approaches, services, or products which heavily impacts the company. However, this also implies that apart from the technological risk that is associated with nearly every type of IT investment (delays, difficult project implementation, or inadequate anticipation of benefits and costs etc.) (Dewan et al., 2007; Maizlish & Handler, 2005), a radical IT innovation's novelty thus usually leads to more complexity for existing routines, processes and the existing IT portfolio's infrastructure (Maizlish & Handler, 2005; Santhanam & Kyparisis, 1996). These extensive consequences to existing systems, servers, and interfaces to other IT objects within the IT portfolio require an even more thorough validation, often more project members and in particular more experienced senior project leaders which need to be pulled off from other IT projects etc. This makes the investment in a rather radical IT innovation highly interdependent to existing activities, projects, and infrastructure within the IT portfolio and thus distinguishes this investment type from normal IT investments.

Additionally, missing best practices or experiences of other companies regarding the comprehension, evaluation, implementation and integration of a radical IT innovation make the estimation of the long-term implications (which also are to consider as highly uncertain) more difficult than those of normal IT investments. Contrary, the required short-term investments for setting up project teams, infrastructure environment, or training usually are higher in contrast to a normal IT investment. On the other side, incremental IT innovations which often are similar to normal IT investments thus usually replace existing infrastructure, applications, or business processes which has a rather low impact and interdependencies to the existing IT.

Taken together, IT innovations differ from normal IT investments mainly by the grade of novelty for the company (whereas incremental and radical IT innovations need to be distinguished). This results in a higher complexity as the implementation can affect the entire IT portfolio's existing routines, staff allocation, processes, and infrastructure. Additionally, a lack of experience and best practices even increase these interdependencies and lead to higher uncertainty about the long-term impact by simultaneously higher short-term investments.

The long- and short-term impact and the risk of IT innovations

Though Wang (2010) empirically demonstrated a positive coherence between investments in very uncertain and immature IT innovations and long-term performance improvements, investments in IT innovations can diverge in two ways from this ideal: IT innovations on one side not always lead to the expected benefits which are required to cover the short-term costs of implementation or even do not create any benefits at all which might lead to a substantial gap between high short-term investments and a significant long-term value contribution (Dos Santos & Peffers, 1995; Fenn & Raskino, 2008; Fichman, 2004). Companies consequently often avoid risky investments in IT innovations. Swanson and Ramiller (2004) thus emphasize mindfulness in IT innovation decision-making by neither applying a pure long-term nor a too short-term orientation. Thus, focusing solely on an IT innovation investment's short-term impact by applying traditional periodical based valuation methods such as Return on Investment (RoI) or Economic Value Added (EVA) most often impedes sustainable value creation in the long run. On the other hand, focusing solely on an IT innovation investment's long-term impact by applying methods like a (risk adjusted) Net Present Value (NPV) can cause problems in the short run due to internal or external reporting pressure or budgetary restrictions. Companies therefore require adequate valuation methods to gain an integrated view on both long term and short term goals (Weill & Broadbent, 1998).

Importance of an IT portfolio approach

To ensure long-term competitive advantage and value creation, companies need to align their IT and thus all IT investment decisions with the overall company strategy. For that, the IT governance structure needs to ensure that a company's IT supports the company-wide strategy while balancing risk versus return of IT and its processes (Weill & Ross, 2004). A company's IT governance in turn determines the IT strategy which is a plan of IT projects and IT investments to assist business in realizing its goals (Gottschalk, 1999). Within this IT strategy, the IT department as well as all related business and functional units systematically need to identify those IT assets, IT projects and other IT artifacts which support the company-wide strategy best (Buchta et al., 2007; Gottschalk, 1999). This results in an IT portfolio that treats the entirety of a company's IT investments as a portfolio of assets similar to a financial portfolio through balancing risk and return adequately (Jeffery & Leliveld, 2004). An IT portfolio usually consists of three kinds of sub portfolios: a) the IT innovation or IT discovery portfolio (e.g., process and product innovations) with rather long-term impact, b) the IT project portfolio (e.g., implementing new IT solutions) with medium- to short-term investments, and c) the IT asset portfolio (e.g., infrastructure) with solely short-term investments (Maizlish & Handler, 2005). As investments within these three sub portfolios differ in their characteristics, more risky investments in IT innovations that often aim at radical changes need to be addressed and evaluated differently than investments in IT assets like new storage or monitors (Maizlish & Handler, 2005; Nagji & Tuff, 2012; Ross & Beath, 2002). The innovation part of the IT portfolio thus is responsible for recognizing technological trends, investment timing, or prioritization and balancing as well as evaluation of different types of IT innovations. As IT nowadays is mostly seen as critical to a company's overall success (Chen et al., 2010), the IT portfolio often gets promoted into a central role in terms of enabling new business models or more efficient business processes. Thus, it often is a starting point for all innovation activities in other business units making it responsible for the communication between all participants and stakeholders inside and outside the IT department like sales, marketing, finance, or human resources that are affected by an IT innovation investment (Chen et al., 2010; Dietze, 2012; Kiessling et al., 2011; Swanson, 1994). The central role of IT innovations within an IT portfolio and their impact on other business units lead to substantial interdependencies between IT innovation investments, the IT portfolio as well as other business units. Thus, the valuation of an IT innovation investment needs to consider these interdependencies to the existing IT portfolio (other IT innovations, IT projects, IT assets) as an IT innovation often enough (or at least partially) might share personnel capacities, experience as well as technical interfaces and require adjustments with existing IT infrastructure, systems etc. (Maizlish & Handler, 2005; Santhanam & Kyparisis, 1996). Though an IT innovation probably might contribute to an IT portfolio in terms of increased return, the associated risks of the IT innovation which even might increase due to the interdependencies need to be addressed according to an IT portfolio approach (Jeffery & Leliveld, 2004; Maizlish & Handler, 2005). Accordingly, such interdependencies need to be incorporated within the valuation of IT innovation investments.

Consequently, as evaluating *normal* IT investments which have more routine already is a challenging task (Irani & Love, 2002; Renkema & Berghout, 1997; Walter & Spitta, 2004), the evaluation of IT innovation investments in particular demands for incorporating the high risks, the enormous time lag between high short-term investments and long-term benefits as well as the high interdependencies with the existing IT portfolio. In the following, we will review existing literature regarding the described aspects and challenges.

Reviewing existing literature

The challenge of determining a *normal* IT investment's value contribution is object of various debates in recent literature (Bannister & Remenyi, 2000; Chan, 2000; Dewan et al., 2007). Chau et al. (2007), Kohli and Grover (2008) or Schryen (2010) – to name but a few – provide an extensive literature, whereas Renkema and Berghout (1997), Sylla and Wen (2002) or Walter and Spitta (2004) in particular address approaches to valuate a single IT investment and their suitability to determine the value of a single IT investment.

Regarding IT innovation investments, literature generally agreed about their importance to gain a competitive advantage and to create economic value (Lim & Stratopoulos, 2008; Stratopoulos & Lim, 2010). Rose and Lyytinen (2001), Swanson (1994), and Grover et al. (1997) state that IT innovations can create value inside the company's IT department, regarding the administration of an entire company, within a company's core business model, and in a company's base technology capability and IT architecture. However, McAfee and Brynjolfsson (2008) and Stratopoulos and Lim (2010) argue that the speed, effectiveness and persistence of a company's IT innovation strategy have a major influence on this positive relationship. Thus, IT innovation investments are no fast-selling item which requires them to be evaluated very thoroughly by incorporating several IT innovation specific characteristics as described above.

Until now, the issue of integrating long- and short-term effects in the valuation of IT investments in general and IT innovation investments in particular has barely been discussed both in general investment valuation and in IS literature. Regarding IS literature, O'Reilly and Tushmann (2008) partially address this topic by providing an approach that stabilizes existing standardized routines in the short-run while simultaneously considering long-term exploring and improvising methods as a basis for innovative new products, services and processes. In addition, Tarafdar and Gordon (2007) analyze how information systems affect long-term process innovations and find different competencies supporting the short-term development and implementation of such innovations. Consequently, they identify the ability to achieve both short-term operational excellence and long-term strategic vision through IT innovations.

Regarding the risks associated with IT investments in general and IT innovation investments in particular, the situation is similar. Although a few articles like Benaroch et al. (2007), Dewan et al. (2007) and Verhoef (2005) explicitly consider IT investment risks, IT innovation literature lacks a broad integration (Dewan et al., 2007; Fichman, 2004; Swanson & Ramiller, 2004; Wang, 2010).

The incorporation of an IT portfolio perspective is approached by several articles like e.g. Fogelström et al. (2010), Zimmermann et al. (2008), Jeffery and Leliveld (2004), Fridgen and Müller (2009), or Reyck et al. (2005). However, they normally focus on the valuation of an existing portfolio in its entirety and so do not support the decision on a single additional IT (innovation) investment. Even though monitoring the performance of an existing IT portfolio in its entirety is certainly important, effective decision making requires the possibility of valuating additional IT investments against the background of the already existing IT portfolio (Jeffery & Leliveld, 2004). Furthermore, existing literature mainly concentrates on the entire IT portfolio without considering the peculiarities of (radical) IT innovations though these might have substantial impact on other business units or affect their innovation activities.

To sum up, there is a rather high research need with respect to the development of adequate methods for the valuation of IT innovation investments considering both, long- and short-term effects as well as the corresponding risk and interdependencies between investments of an IT portfolio. To bridge this research gap, this paper aims at developing an approach for an integrated long- and short-term valuation of IT innovations by drawing on existing approaches from IT portfolio and IT innovation management literature. Thereby, our valuation approach is based on the "With and Without Principle" idea from financial theory (Merton & Perold, 1993) in combination with a Net Present Value (NPV) (Copeland et al., 2008). Consequently, we define the value contribution of an IT innovation investment as the difference between the value of an existing IT portfolio *with and without* the realization of the additional IT innovation investment. Thus, the whole increase or decrease of the IT portfolio's value is attributed to the new investment as the source of this variation. Therefore, we speak of a "source-based" determination of an IT innovation investment's value contribution. The integrated view on both long- and short term objectives enables top management to address the described trade-off with regard to the valuation of IT innovation investments by reflecting the management's target weighting.

III.1.3 Towards an Integrated Long- and Short-term Valuation of IT innovation Investments

Value contribution of an IT innovation and financial valuation of IT innovation investments

Following Kauffman and Weill (1989) as well as the analysis in Walter and Spitta (2004), the best IT investments are the ones that help maximizing the value of a company. Thus, the value contribution of an IT investment should be determined by its quantitative, financial impact on the company (Primrose, 1990), measured on the basis of future net cash flows (Probst & Buhl, 2012; Walter & Spitta, 2004). This seems reasonable for several reasons: First, this approach supports a value-based management and value-creation as a concretization of the shareholder value principle, which aims at maximizing the net present value of all future cash flows (Buhl et al., 2011). Second, valuating IT investments based on their net cash flows ensures objective valuation without influence by accounting policies. Third, cash flow approaches build the quantitative, monetary basis within ex ante IT investment valuation which in a second step can be extended by qualitative criteria (Irani & Love, 2002). In line with this conception of an IT investment's value contribution, numerous papers have dealt with the application of various methods from financial theory to valuate IT investments on a monetary base. To name but a few, Bardhan et al. (2004), Benaroch et al. (2007), Benaroch and Kauffman (1999), Fichman et al. (2005), or Taudes et al. (2000) apply approaches based on real option theory to especially capture the value of flexibility of IT investments. Ullrich and Braunwarth (2010), Erdogmus (2005), Kumar (2004), or Schober and Gebauer (2011) apply the well-known decision tree approach the model dynamic decision structures within different IT investment settings. Furthermore, Fridgen and Moser (2013), Probst and Buhl (2012), Zimmermann et al. (2008), or Zimmermann et al. (2012) adapt Markowitz's portfolio selection theory for optimizing various types of IT portfolios (e.g., IT service portfolio, IT innovation portfolio) considering a risk-/return trade-off. Next to research, the evaluation on the basis of financial aspects is widely applied in practice within IT (innovation) controlling (Buchta et al., 2007; Daum, 2007) and based on measurable determinants like increased productivity (in sales), better market reach (e.g. in strategic marketing), reduced time for reporting (in controlling), reduced failure rates (in production), increased customer satisfaction (in marketing), decreased response time or increased speed of IT service deployment (in IT department), or better data quality (in customer data management).

Despite the widespread use of methods from financial theory for valuating IT investments in theory and practice, their transferability to issues of IT investment valuation needs to be critically discussed for each specific case (Asundi & Kazman, 2001; Verhoef, 2002). This is particularly due to the fact that many methods from financial theory were initially developed to deal with financial assets and thus are often based on rather restrictive assumptions that are tied to the specifics of financial commodities and capital markets (like real options which require an adequate twin security for calculating stage-contingent) (Copeland et al., 2008). In contrast, we in our paper apply a rather straightforward approach based on the concept of a risk adjusted NPV (Copeland et al., 2008). The concept of a risk adjusted NPV is associated with considerably less restrictive assumptions and thus is applicable for the valuation of IT (innovation) investments without major constraints. In line with this, several papers like Irani and Love (2002), Irani (2010), or Renkema and Berghout (1997) emphasize the concept of NPV as one suitable approach to valuate IT investments on a financial base. As any other financial valuation method, the NPV approach, of course, requires an initial estimation of the IT (innovation) investment's cash flows. But even though it is challenging to estimate financial impacts like cash flows reliable without uncertainty, it is useful and possible to rank and prioritize IT investment alternatives on the basis of financial analysis as "[…] even when true investment values are not obtainable" (Clemons & Weber, 1990, p.19).

Decision problem and model setup

To support the decision-making process, we in our paper develop an analytical model which determines an IT innovation's value contribution. We determine this value contribution by a risk-adjusted NPV and particularly focus on the integrated view on both, the short-term as well as the long-term value contribution. For that, we combine the two value contributions by a weighting factor which illustrates a company's attitude towards the importance of an IT innovation's short- or long-term implications. By that, we are able to depict the corporate innovation strategy which might either focus on the short-term implications or a rather early adopter view with focus on the long-term implications. We consider the risk of the IT innovation investment in terms of its cash flow's variance. Also, we incorporate interdependencies between the IT innovation investment and the existing IT portfolio (i.e., existing processes, IT infrastructure, staff) which we measure by correlations between the IT innovation's and the IT portfolio's cash flows.

Application Example

To demonstrate a real world decision problem which can be supported by our approach, we in the following provide an example of application which is based on a real world business problem from an industry project.

The Helto Group globally develops, produces, and markets tools for industries like building, construction or maintenance. Helto distributes its products via a direct sales model with a worldwide number of ~10,000 sales representatives which account for ~65% of annual sales, an online shop (~20% of annual sales) and Helto Pro shops (~15% of annual sales). On a basis of more than nine million customer base entries, two of three employees have daily customer contact leading to more than 200,000 customer contacts, more than 50,000 sales orders and 150,000 order item entries per day across all channels. These leads to a giant data volume which needs to be managed and reported across the whole value chain, starting from sales, logistics, finance, human resources or marketing. To accelerate daily and monthly reporting which currently takes up to twelve hours for all extraction, transaction and loading (ETL) processes as well as massive support by controlling staff, Helto needs to enhance its data base structure for both, online analytical processing (OLAP) regarding daily reporting as well as online transactional processing (OLTP) for setting the basis for worldwide usage of future developments like Cloud Computing or mobile app support of the sales representatives. Helto therefore has pre-evaluated possible alternatives for enhancing its data base structure and currently has to decide between two IT innovations to invest in:

A) **IT innovation A: Implementing an in-memory data base system (IMDBS)** like SAP HANA or Oracle Exalytics for OLAP and optimize the existing relational database system (RDBS) for OLTP applications. In the long-term Helto aims to fusion its OLAP and OLTP within one data base.

Due to the possibilities of real-time analyses which are enabled through an IMDBS, Helto in the long-term would be able to accelerate daily or monthly reporting from up to twelve hours to approximately 30 seconds which increases productivity and enables the controlling team to deal with more value generating activities. Also, Helto could track and analyze worldwide sales, orders, customer comments, or return deliveries in real-time. This would allow for extreme fast decision making, adaption of marketing campaigns, optimized logistic routes or targeted customer contact which increases sales, market share, productivity and consequently leads to increased positive cash flows. Also, the basis for real-time data on mobile devices would be set which in future could be used to optimize customer recommendations on construction grounds or to handle requests regarding order status in real-time which additionally would increase productivity, sales and thus cash flows. All in all, Helto expects higher long-term returns by this solution due to the described benefits. However, IMDBS technology currently is still in development phase (Gartner, 2012) and Helto would be a pilot user which cannot draw on former companies and their experiences, best practices etc. Various phases of parallel running, migration tests and own tool development as well as the support of external consultants would be required to enable compatibility with the existing applications, services, routines etc. This leads to extensive impact on Helto's IT department in the short- and long-run, a high involvement of senior project managers, business unit partners (e.g., from marketing, finance) and external consultants from the IMDBS provider whereas especially latter generates substantial short-term costs. Additionally, such a radical IT innovation comes along with substantial interdependencies with the existing IT portfolio as it simultaneously would access and impact existing routines, infrastructure (e.g., data storage) and other resources like senior project managers or data-base experts.

B) **IT innovation B: Implementation of an advanced relational database system (RDBS)** like IBM DB2 version 10.5 in combination with a new data ware house (DWH) application which covers both, OLAP and OLTP and migration of existing 60 data bases on one core RDBS.

In contrast to a rather radical concept like IMDBS, the advantage of a rather mature and thus incremental advanced RDBS are maturity, existing best practices and experiences within Helto and external consultants as well as a broad range of applications, tools and compatible software. Additionally, costs for licensing fees, future running- and maintenance, the required storage for the data base as well as data protection and backup are significantly lower and better to estimate. The possibility of an easier integration and limited impact on existing activities within the IT portfolio also leads to lower interdependencies between the advanced RDBMS alternative and the IT portfolio. The investment in IT innovation B with its central data base structure and quicker calculations allows Helto quicker OLTP as well as OLAP (which leads to better data quality, thus less maintenance costs as well as increased positive cash flows due to increased productivity). However, it does not allow for extraordinary new business returns which might result from real-time decision making or data analyses regarding information like regional sale activities, real-time campaign tracking or real-time reporting for sales representatives, regional managers or corporate controlling.

Helto now in t=0 has to decide about whether to invest in one of the proposed IT innovations and whether **IT innovation A (IMDBS)** or **IT innovation B (advanced RDBS)** contributes better to the existing IT portfolio but also supports the needs of the business units best. Thereby, the IMDBS alternative as a more radical innovation aims on higher (but more uncertain) long-term value contribution while inheriting rather high risks and substantial short-term investments as well as very high interdependencies with the existing IT portfolio as well as other business processes and applications. Though the RDBS alternative’s value contribution is estimated to be lower, it is better to estimate, can be realized earlier and comes along with lower short-term investments. Also, existing best practices and internal experience lower the risk of the possibly negative impact on existing IT and business. Depending on how Helto weights the long- as well as short-term implications, the risk as well as the interdependencies with the existing IT portfolio strongly influence the advantageousness of the respective investments. Hence, we in the following present a model which supports this business decision by determining the value contribution of an IT innovation.

To be able to deal with the described valuation setting needs methodological rigor models which deliver reasonable results even though they might not be applicable without adjustments. To enable a rigorous definition and presentation of our model, we in the following denote it in a formal-deductive mathematical way which implicates assumptions that we state in the following.

Notations and assumptions

The time interval under consideration consists of discrete, equidistant points of time $\mathrm{t} = 0, 1, \dots, \mathrm{T}$, $\mathrm{T} \in \mathbb{N}$, where $\mathrm{t} = 0$ denotes the beginning and $\mathrm{t} = \mathrm{T}$ the end of the planning horizon. The company's IT portfolio PF at time $\mathrm{t} = 0$ consists of $\mathrm{n} \in \mathbb{N}$ IT innovation investments, which generate the IT portfolio's total stochastic cash flow $\overrightarrow{\widetilde{\mathrm{CF}}}^{\mathrm{PF}} = (\widetilde{\mathrm{cf}}_0^{\mathrm{PF}}, \dots, \widetilde{\mathrm{cf}}_\mathrm{T}^{\mathrm{PF}})$. The company furthermore decides at time $\mathrm{t} = 0$ whether to invest in a new IT innovation investment $\mathcal{I}$, which is characterized by the total stochastic cash flow $\overrightarrow{\widetilde{\mathrm{CF}}}^{\mathcal{I}} = \left(\widetilde{\mathrm{cf}}_0^{\mathcal{I}}, \dots, \widetilde{\mathrm{cf}}_\mathrm{T}^{\mathcal{I}}\right)$, or not. If the IT innovation investment ends at time $\mathrm{t} = \mathrm{T'} \in \mathbb{N}$ with $1 \leq \mathrm{T'} < T$, one has: $\widetilde{\mathrm{cf}}_\mathrm{t}^{\mathcal{I}} = 0$ for all $\mathrm{T'} < t \leq T$. In case, the company invests in the additional IT innovation investment $\mathcal{I}$, the composition of its IT portfolio will change. Certainly, focusing solely on an IT portfolio without firmly modeling the interrelation with other business units like marketing is simplifying matter. However, as the IT portfolio plays a central role for innovations inside and outside the IT department (Chen et al., 2010; Kiessling et al., 2011; Swanson, 1994), we consider modeling the IT innovation's value contribution to the IT portfolio in a first step as appropriate as the IT portfolio then again contributes to the value of other business units and thus the company. The company's new IT portfolio PF^* (after investing in the IT innovation) generates the total stochastic cash flow $\overrightarrow{\widetilde{\mathrm{CF}}}^{\mathrm{PF}^*} = (\widetilde{\mathrm{cf}}_0^{\mathrm{PF}^*}, \dots, \widetilde{\mathrm{cf}}_\mathrm{T}^{\mathrm{PF}^*})$, where $\widetilde{\mathrm{cf}}_\mathrm{t}^{\mathrm{PF}^*} = \widetilde{\mathrm{cf}}_\mathrm{t}^{\mathrm{PF}} + \widetilde{\mathrm{cf}}_\mathrm{t}^{\mathcal{I}}$ denotes the periodical stochastic cash flow of the company's new IT portfolio at time $\mathrm{t} = 0,1, \dots, \mathrm{T}$. For the sake of simplicity, we make the following assumption 1 for the periodical stochastic cash flows $\widetilde{\mathrm{cf}}_\mathrm{t}^{\mathrm{PF}}$ and $\widetilde{\mathrm{cf}}_\mathrm{t}^{\mathcal{I}}$:

Assumption 1: *Each periodical stochastic cash flow $\widetilde{cf}_t^{PF}$ and $\widetilde{cf}_t^{\mathcal{I}}$ $(t = 0,1, \dots, T)$ is normally distributed with expected value μ_t^{PF} and $\mu_t^{\mathcal{I}}$ as well as standard deviation σ_t^{PF} and $\sigma_t^{\mathcal{I}}$, i.e. $\widetilde{cf}_t^{PF} \sim N(\mu_t^{PF}, \sigma_t^{PF})$ and $\widetilde{cf}_t^{\mathcal{I}} \sim N\left(\mu_t^{\mathcal{I}}, \sigma_t^{\mathcal{I}}\right)$. As consequence of assumption 1,*

$\widetilde{cf}_t^{PF^*}$ *is also normally distributed with expected value* $\mu_t^{PF} + \mu_t^{J}$ (Zimmermann et al., 2012).

Though assuming normally distributed cash flows is simplifying reality as an IT innovation's cash flow might also follow another distribution, the use of a normally distributed stochastic cash flows is common in literature regarding IT investments (Dewan & Ren, 2011; Fridgen & Müller, 2009; Probst & Buhl, 2012; Zimmermann et al., 2008). As IT innovations might lead both, to an upward as well as a downward deviation from the expected cash flow, normally distribution suits our decision problem as a realistic assumption. For that, and to follow established methods of investment theory (Copeland et al., 2008; Freund, 1956) we propose to use a risk adjusted NPV to consider the IT innovation investment's impact on the IT portfolio value. By applying the "With and Without Principle" (and thus defining the value contribution of an IT innovation investment as the difference of the IT portfolio's value with and without investing in this investment), we first need to calculate the NPV of an IT portfolio's total stochastic cash flow. Second, we have to adjust the expected value of this NPV with the corresponding risk. Therefore, we draw on the variance of the NPV as a standard risk measure. However, the periodical cash flows that can result from an IT innovation investment usually are not independent from the existing IT portfolio's structure, characteristic, riskiness or stability. Instead, there are stochastic interdependencies between investments within an IT portfolio like limited technological or human resources (structural or intratemporal interdependencies, i.e., they occur at the same time) (Santhanam & Kyparisis, 1996). As an example, there might occur the situation where a data-base manager with in-depth knowledge regarding in-memory systems also is needed in another must-be IT-project which addresses regulatory aspects leading to a lack of project experts. Within the IT portfolio, the IT department needs to consider that for such investments in new technologies, senior project leaders are required which then might miss in other projects which are conducted at the same time. A radical new IT innovation also might require a substantial amount of interfaces to other systems or build on platforms which then might not be available for other applications or services (e.g., web services, data storage). Naturally, such interdependencies (which also illustrate whether an IT innovation rather replaces or complements parts of the existing IT portfolio as a complementary system usually has a higher impact on the existing IT portfolio with higher interdependencies) not only occur within the IT portfolio but also with employees or systems from business units across the company. However, we for reasons of simplicity limit the modeling on the interdependencies within the existing IT portfolio which by itself then also is correlative with these business units. We model these interdependencies between an IT innovation project P and the existing IT portfolio PF in terms of correlations $\rho_{m,m}^{P,PF}$ between the periodical stochastic cash flows $\widetilde{cf}_m^P$ and $\widetilde{cf}_m^{PF}$ with $\rho_{m,m}^{P,PF} \in [0,1]\ \forall\ m = 0, \dots, T$. As the IT innovation can affect the IT portfolio's cash flows in two ways, negatively by decreasing them through more costs as well as positively by complementing the IT portfolio which leads to increased cash flows, incorporating these interdependencies are from major importance. Summing up, we can thus make the following assumption with regard to value of an IT portfolio:

Assumption 2: *The value V^i of an IT portfolio ($i = PF^*$ or $i = PF$) at the valuation date $t = 0$ is measured by a risk adjusted NPV which integrates the corresponding total stochastic cash flow's $\overrightarrow{\widetilde{CF}^i}$ ($i = PF^*$ or $i = PF$) expected NPV, its variance and the company's risk aversion α > 0 and is defined via*

$$V^i = \mu\left(NPV\left(\overrightarrow{\widetilde{CF}^i}\right)\right) - \frac{1}{2} \cdot \alpha \cdot \sigma^2\left(NPV\left(\overrightarrow{\widetilde{CF}^i}\right)\right)$$

Similar approaches to IT investment valuation have been applied in related contexts over the last decades (Hanink, 1985; Zimmermann et al., 2012). The parameter α indicates the company's individual level of risk aversion (Arrow, 1971), whereas a higher value of α indicates a higher risk aversion. As an IT portfolio's innovation sub-portfolio by definition deals with riskier investments than, for example, an IT asset portfolio (which deals with infrastructure, operational data and routine processes), a risk parameter α>0 should not be put on a level with a non-innovative decision maker or laggard who neglects innovations completely by putting high emphasis on the risk. To determine the value of α, Bamberg and Spremann (1981) generally or Beer et al. (2013) specifically for IT investments suggest methods which are based on surveys or scenario-based interviews with the decision makers. According to common statistics, the afore-mentioned correlations become relevant when determining the NPV's variance. Based on these assumptions we can develop a method for an integrated long- and short-term a priori valuation of IT innovation investments in the next following.

Integrated long- and short-term valuation

In order to integrate the long- and short-term effects of a single IT innovation investment, we propose a two-stage approach: First of all, we independently derive both, a long- and a short-term value contribution of the IT innovation investment in order to model each effect separately while simultaneously considering stochastic interdependencies with and without realizing the regarded IT investment $\mathcal{I}$. Second, we combine these long- and short-term value contributions to facilitate an integrated long- and short-term valuation of a single IT innovation investment. By that, we can incorporate a company's long- and short term strategy or weighting of each perspective within one valuation method.

Long-term value contribution of the IT innovation investment

The long-term value contribution is based on the IT portfolio's total value $\mathrm{V^i}$ with $\mathrm{i} \in (\mathrm{PF}, \mathrm{PF}^*)$ and models the long-term increase in the IT portfolio's value due to the regarded IT innovation investment $\mathcal{I}$. That is the value contribution, an IT innovation investment can realize after being completely conducted and after all parts of this IT innovation investment are completely delivered. In our example for the IMDBS alternative (IT innovation A), this would comprise for the whole implementation phase with alignment of business processes within the IT department and other business units and also the stabilized phase in which a productive use of the new data base structure is possible. Latter then generates positive cash inflows and value through creating competitive advantage on the basis of new business models (e.g., through faster reporting or real-time analytics). To determine this long-term value contribution $\mathrm{VC_L}$, we calculate the IT portfolio's total value $\mathrm{V^i}$ both, *without* running the IT innovation investment ($\mathrm{i} = \mathrm{PF}$) (i.e., with the current database and no investment in IT innovation A or B) and *with* running the IT innovation investment ($\mathrm{i} = \mathrm{PF}^*$) (i.e., after investing in IT innovation A or B). For that, we apply the formula from assumption 2 and incorporate *all* periodical cash flows $\widetilde{\mathrm{cf}}_0^{\mathrm{i}}, \dots, \widetilde{\mathrm{cf}}_\mathrm{T}^{\mathrm{i}}$, $\mathrm{i} \in (\mathrm{PF}, \mathrm{PF}^*)$. We hence obtain the long-term value contribution VC_L of the IT innovation investment by calculating the difference between the two IT portfolio's total values via

$$VC_L = V_L^{PF^*} - V_L^{PF}$$

Short-term value contribution of the IT innovation investment

In contrast, the short-term value contribution reflects the implication of the IT innovation on the IT portfolio's value within the early phase of its lifecycle. We thereby consider only the first periods of the IT innovation investment by incorporating solely the very first periodical stochastic cash flows of the IT portfolio with and without realizing the regarded IT investment $\mathcal{I}$. To determine the IT innovation investment's short-term value contribution VC_S we first choose an integer $k \in \{0, \ldots, T'\}$ which identifies the first k periods of the IT innovation investment $\mathcal{I}$, that are supposed to be included in the short-term value contribution of the IT innovation investment. In practice, this time frame addresses financial issues (e.g., through an IT controlling representative), the view of the IT innovation and IT strategy (e.g., the head of IT innovation management) and other business units. Regarding an investment in IMDBS, this time frame usually would focus on the rather risky implementation phase or the phase until the IT innovation board expects the IT innovation to run stable and productive which by nature often leads to a negative value contribution. As an example from internal product innovation management, Proctor & Gamble sells internal developments to the market in case they have not been used productively after three years (Van der Meer, 2007). Choosing the value of k thereby mainly depends on two influencing factors: First, the value of k is influenced by the length, the company estimates the IT innovation to be in a risky phase (with majorly cash-outflows) until it creates a positive value contribution. For that, market research as conducted by Gartner Group in its Hype Cycle method (Fenn & Raskino, 2008; Gartner, 2012) can be helpful to become an idea of how to determine k or when the company needs to switch from the old data base structure to the new one etc. Second, the value of k also depends on the length of a company's short-term financial planning horizon as well as on the number of periods for which a company publishes periodical risk/return ratios in advance for the purpose of external and/or internal reporting. Subsequently, we calculate the IT portfolio's short-term value V_s^i both, without running the IT innovation investment $(i = PF)$ and with running the

IT innovation investment ($\mathrm{i} = \mathrm{PF}^*$) by applying the formula from assumption 2, but now only consider the NPV of the cash flows $\widetilde{\mathrm{cf}}_t^{\mathrm{PF}^*}$ and $\widetilde{\mathrm{cf}}_t^{\mathrm{PF}}$ with $\mathrm{t} = 0,1,\dots,\mathrm{k}$. We hence obtain the short-term value contribution $\mathrm{VC_S}$ by calculating the difference between the two short-term values of the IT portfolio via

$$\mathrm{VC_S} = \mathrm{V}_s^{\mathrm{PF}^*} - \mathrm{V}_s^{\mathrm{PF}}$$

Combination of the long- and short-term value contribution

For the integrated long and short-term valuation of an IT innovation investment in a portfolio context we combine the already defined value contributions of the IT innovation investment following the well-accepted Hurwicz-principle (Hurwicz, 1951) from decision theory. We thus obtain a mean average of the two value contributions via

$$\phi(\lambda, \mathrm{VC_S}, \mathrm{VC_L}) = \lambda \cdot \mathrm{VC_S} + (1-\lambda) \cdot \mathrm{VC_L} \quad \text{with } \lambda \in [0,1]$$

The Hurwicz-principle represents a suitable compromise between the MaxMin and the MaxMax-principle. In terms of this paper this means a compromise between a pure concentration on the IT innovation investment's long-term value contribution (λ=0) and a pure concentration on its short-term profitability (λ=1). Other established decision rules such as the Laplace- or Savage-Niehans-principle (Laplace, 1902; Savage, 1951) do not allow for this integration. Again, the weighting parameter needs to incorporate both, the view of the financial perspective, the IT innovation and IT strategy perspective but also the view of business units (e.g., sales) and the corporate strategy. To enable an alignment of the company-wide strategy as well as IT strategy, this parameter needs to reflect the company's view on long-term as well as short-term implications. The factor might be determined for every single IT innovation investment decision or there might be a centrally defined default value for certain kinds of IT innovations. Whereas radical IT innovations investments with a long-term character might demand for a lower value of λ, incremental IT innovations that aim at optimizing existing products or processes with short-term implications might demand for a higher value of λ. Regarding a company's IT innovation strategy and the role, the IT plays for the company's business model, this parameter measures the company's weighting of the IT innovation's long-term implications (i.e., $\lambda = 0$ reflects a systematic early adopter strategy that only concentrates on the long-term impact) as well as its short-term implications (i.e., $\lambda = 1$ reflects an innovation laggard strategy that solely focuses on short-term aspects). Hence, the application of this principle is appropriate for addressing our research question of integrating both views in one valuation approach. Attention should be furthermore paid because $\lambda = 0.5$ in general does not indicate a par for par weighting of the value contributions due to possible size differences between the two value contributions (VC_S, VC_L). In the following, we will analyze the proposed valuation approach in more detail by conducting sensitivity analyses for the most relevant model parameters.

III.1.4 Analysis of the Valuation Approach

For analyzing the advantageousness of the IMDBS alternative (IT innovation A) or the advanced RDBS (IT innovation B), we in the following conduct a sensitivity analysis to analyze the IT innovation investments' long and short-term integrated value contribution ϕ by varying certain input parameters of the model. We will conduct sensitivity analyses with respect to the variance of the total stochastic cash flow of the IT innovation A, the intratemporal correlation between the IT innovation investment A and the IT portfolio as well as the weighting parameter λ .

Sensitivity Analysis

Sensitivity analysis is a common method from decision-making theory and aims on examining how sensitive a model's results (e.g., profit) are to changes regarding the values of the input variables the decision maker needs to incorporate in the decision making process (Kim et al., 2009; Pannell, 1997; Saltelli et al., 2008; Triantaphyllou & Sánchez, 1997). In its basic form as applied in our analysis which is rather easy to apply in practice, the decision maker changes the values of a certain input variable between a minimum and a maximum value by keeping all others constant and repeats this with every input variable of interest (Pannell, 1997; Saltelli et al., 2008). Regarding the behavior of certain parameters, the major objectives are to test the robustness of the model's results in the presence of uncertainty about the parameterization of certain input values and to gain a deeper understanding about the relationships between the model's input variables and the outcome (e.g., the relationship between the value contribution of an IT innovation $\phi(\lambda, VC_S, VC_L)$ and the weighting factor λ). By doing that, sensitivity analysis allows identifying those input variables which have the strongest impact on the model's outcome and which need to be in the focus of the analysis. During the model setup, sensitivity analysis can contribute to eliminate errors by unfolding irrational correlations between input and results as well as to identify possible model simplifications. Sensitivity analysis also is a suitable to derive managerial implications as it helps to illustrate the model's results, make it more credible and easily allows for demonstrating the impact of changing input variables which in practice often are difficult to estimate properly. Thus, it enables decisions on where the company should invest more in efforts like data collection, risk reduction, resource allocation or where simplifying assumptions can be applied. However, sensitivity analysis in its simple form neglects possible interrelations between different input variables and is not able to measure the effect on multiple output variables (Saltelli et al., 2008; Triantaphyllou & Sánchez, 1997). As our model requires only a limited number of core input variables which are not interrelated between each other, this weakness of sensitivity analysis does not distort the general results of our model's analysis.

Within our sensitivity analysis, we apply the fictive rounded input values in Table III.1 for the two IT innovation investments A and B as well as the company's IT portfolio PF. Though we assume fictive initial values, they depict the different characteristics of the IT innovations regarding long- and short-term implications, risk etc. quite well and so allow for demonstrating the model's usefulness for business decisions according to a real world business problem. Furthermore, we assume a risk free rate of 3%, a risk aversion of α=1 (which indicates a rather risk-averse decision maker) and a short-term planning horizon of k=3 periods as for IMDBS, which is the focus of our analysis,, approximately three years are expected for broad institutionalization and productive usage (Gartner, 2012). For measuring risk, we for A assume the initial variance to be 10% of the estimated cash flows. For B, we estimate the variance to be lower with 5% of the estimated cash flows. The influence of changing the variance is shown in a later sensitivity analysis. For A, we initially assume a rather high interdependency with the existing IT portfolio (results in a higher correlation of $\rho_{m,m}^{A,PF} = 0.6 \ \forall \ m = 0, \dots, T$) and a lower correlation for B as its interdependency with the existing IT portfolio is lower (resulting in a rather low correlation of $\rho_{m,m}^{B,PF} = 0.4 \ \forall \ m = 0, \dots, T$). In a later sensitivity analysis, we will illustrate how different values for the correlation influence the model's results.

Table III.1: Input values for the sensitivity analyses of the valuation approach

t		0	1	2	3	4	5
A	$\mu\left(\widetilde{cf}_t^A\right)$	-200	-200	260	260	325	325
	$\sigma^2\left(\widetilde{cf}_t^A\right)$	20	20	26	26	32.5	32.5
B	$\mu\left(\widetilde{cf}_t^B\right)$	-120	-120	200	200	250	250
	$\sigma^2\left(\widetilde{cf}_t^B\right)$	6	6	12	12	15	15
PF	$\mu\left(\widetilde{cf}_t^{PF}\right)$	1,000	1,050	1,103	1,158	1,216	1,276
	$\sigma^2\left(\widetilde{cf}_t^{PF}\right)$	50	53	55	58	61	64

To enable an easier interpretation of the analysis part, Table III.2 summarizes all major parameters which are relevant for the sensitivity analyses which follow in the next paragraphs.

Table III.2: Input values for the sensitivity analyses of the valuation approach

Variable	**Description / Initial value**
IT innovation A	Implementing an **In-memory data base system (IMDBS)**
IT innovation B	Implementing an **advanced relational data base system (RDBS)**
$\rho_{m,m}^{A,PF}$	**Correlation between the IT innovation A and the existing IT portfolio;** Initial value: $\rho_{m,m}^{A,PF} = 0.6 \ \forall \ m = 0, \dots, 5$
λ	**Weighting parameter** (i.e., $\lambda = 0$ reflects a systematic early adopter strategy that concentrates on the long-term impact)
$\phi(\lambda, VC_S, VC_L)$	**Long- and short term integrated valuation** of IT innovation A / IT innovation B $(\lambda, VC_S, VC_L) = \lambda \cdot VC_S + (1-\lambda) \cdot VC_L$ with $\lambda \in [0,1]$
$\sigma^2\left(\widetilde{cf}_t^A\right)$	**Risk of IT innovation A** (i.e., variance of the cash flows that result from IT innovation A)
$\sigma^2\left(\widetilde{cf}_t^{PF}\right)$	**Risk of IT portfolio PF** (i.e., variance of the cash flows that result from the IT portfolio before any investment is conducted)

As IT innovation A (IMDBS alternative) depicts the idiosyncrasies of a radical IT innovation investment more in particular and thus shows the approach's usefulness, we in the following analyses mainly focus on the results and parameters of IT innovation A.

Variance of IT innovation investment A

Figure III.1 shows the results of the sensitivity analysis regarding the impact of the risk (i.e., the variance $\sigma^2\left(\widetilde{cf}_t^A\right)$) of the IMDBS alternative (IT innovation A) on the long and short-term integrated value contribution $\phi(\lambda, VC_S, VC_L)$ of IT innovation A and B. The drawn through lines represent the value contribution of IT innovation A and the dotted lines show the value contribution of reference investment B. To analyze how the risk of an IT innovation affects the results, we change the variance of the stochastic cash flows of IT innovation A ($\sigma^2(\widetilde{cf}_t^A)$) as this investment alternative is the focus of our analysis:

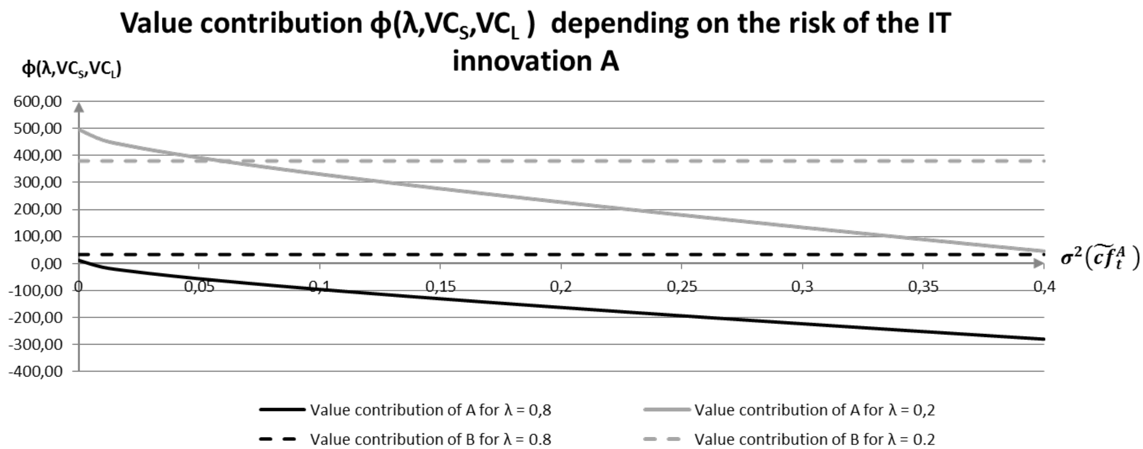

Figure III.1: Sensitivity analysis regarding the IT innovation A depending on the risk of IT innovation A.

For each investment the grey lines show the development of the value contribution when taking a rather long-term oriented perspective ($\lambda = 0.2$) whereas the black lines represent the value contribution for a more short-term oriented one ($\lambda = 0.8$). As the integrated long- and short-term value contribution of IT innovation B is not affected by the risk of IT innovation A, the values for B consequently stay constant within this analysis and only are affected by a changed scenario regarding λ. According to Figure III.1, the value contribution of IT innovation investment A declines with an increasing variance of its total stochastic cash flow for both manifestations of λ. This is in line with the underlying concept of a risk-adjusted NPV where the expected NPV of an investment is lowered by the risk of the stochastic NPV. The sharp drop of A's value contribution when raising variance from 0% to 1% is explained by the fact that in case of a positive variance of investment A also the covariance to the IT portfolio has to be taken into account (based on an assumed correlation of $\rho_{m,m}^{A,PF} = 0.6 \;\forall\, t = 0, \dots, 5$ between A and the IT portfolio). Compared with the reference investment B which generally is characterized by lower risk, a long-term oriented decision maker ($\lambda = 0.2$) would prefer investment A up to a variance of about 6.5%. For every variance higher than 6.5%, the decision maker will neglect investment A and instead choose the reference investment B (assuming a stable variance of 5% as in this analysis). Considering the high immaturity of IMDBS which underlies IT innovation A, a variance of only 6.5% seems to be very optimistic making this investment rather unfavorable from a risk perspective in this parameter setting. A short-term oriented decision maker ($\lambda = 0.8$) will never decide upon investment A as it generates a lower value contribution then reference investment B even in case of being completely riskless. This is due to the high investment spending of investment A in the first two periods (e.g. developing own tools which are compatible to the IMDBS, new data storage) making this investment alternative unfavorable in a short-term view. These results provide several implications: First, when applying our approach, a more short-term oriented company might invest in IT innovation B (RDMBS) and avoid costly and risky investments in a rather immature IT innovation A like IMDBS that tends to pay out only in the long-run, if any. Second, IT innovation investment decisions generally should consider the risk of an IT innovation investment as well as long and short-term impacts as both aspects heavily affect an investment's value contribution and thus investment decisions.

Correlation between IT innovation investment A and the IT portfolio

Figure III.2 shows the results of the sensitivity analysis regarding the impact of the intratemporal correlation between the IT innovation investment A and the IT portfolio on the value contribution $\phi(\lambda, VC_S, VC_L)$:

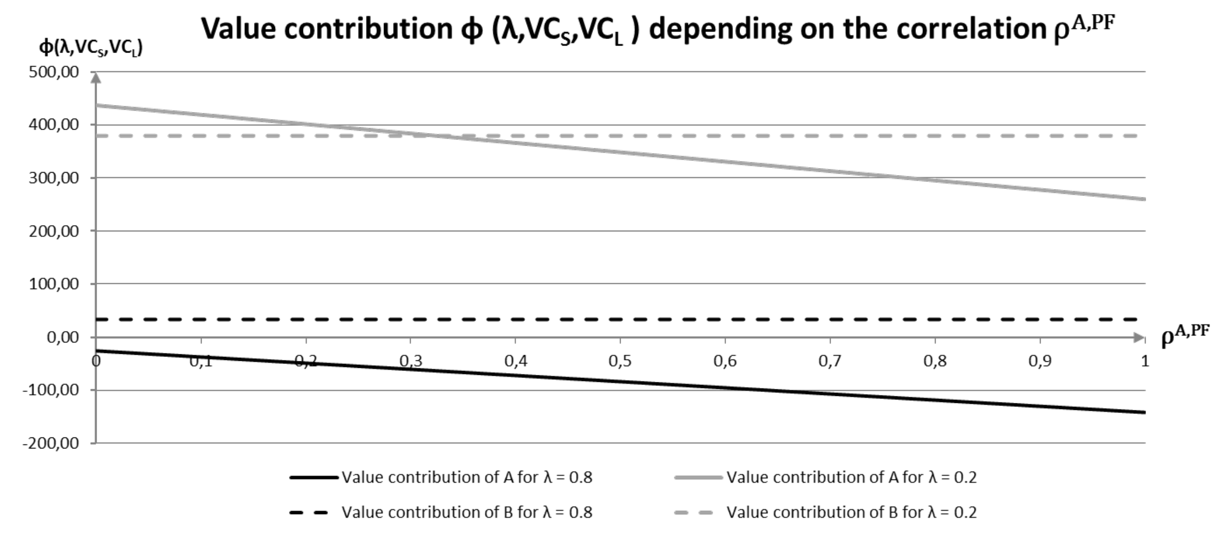

Figure III.2: Sensitivity analysis regarding the correlation between IT innovation A and the existing IT portfolio PF.

Using an illustration analogous to Figure III.1, one can see that the value contribution of A declines with an increasing intratemporal correlation between investment A and the IT portfolio. This is due to the basic idea of the with-and-without principle claiming that all risks induced by a certain investment have to be attributed to that very investment. Consequently, also the covariance-risk that arises through implementing a rather immature IT innovation like an IMDBS in the existing IT infrastructure has to be attributed to investment A and thus reduces its value contribution. The overall risk of investment A thereby is mainly driven by this covariance-risk and not by its stand-alone variance. Hence, IT innovation investments might be evaluated positively despite their very high stand-alone risk if they are only weakly correlated to the existing IT portfolio. This effect can also be observed in Figure III.2: A rather long-term oriented decision maker ($\lambda = 0.2$) will prefer IT innovation investment A up to a correlation of about 0.32 although this investment shows a very high stand-alone risk compared to reference investment B ($\sigma^2(\widetilde{cf}_t^A) = 10\%$ vs. $\sigma^2(\widetilde{cf}_t^B) = 5\%$). Only for correlations higher than 0.32 the decision maker will decide upon reference investment B. However, as we initially assume the interdependencies between an IMDBS and the existing IT portfolio, business processes and applications to be rather high, a correlation of 0.32 seems very low and unrealistic. Thus, according to our approach, an IMDBS might not be favorable. Analogous to the previous analysis, a short-term oriented decision maker

($\lambda = 0.8$) will never decide upon investment A as it generates a lower value contribution then reference investment B even in case of being completely uncorrelated to the IT portfolio.

Long- and short-term weighting λ in case of low/high risk of the IT portfolio

In this part, we will finally analyze how the value contribution of an IT innovation investment depends on the weighting parameter λ. Thereby, we will consider various IT portfolios within the sensitivity analysis that differ regarding their risk position ($\sigma^2\left(\widetilde{cf}_t^{PF}\right) = 5\%; 10\%; 20\%$). In doing so, we are able to simultaneously investigate how the risk position of the already existing IT portfolio affects the value contribution of new IT innovation investments. The results of the sensitivity analysis are shown in Figure III.3:

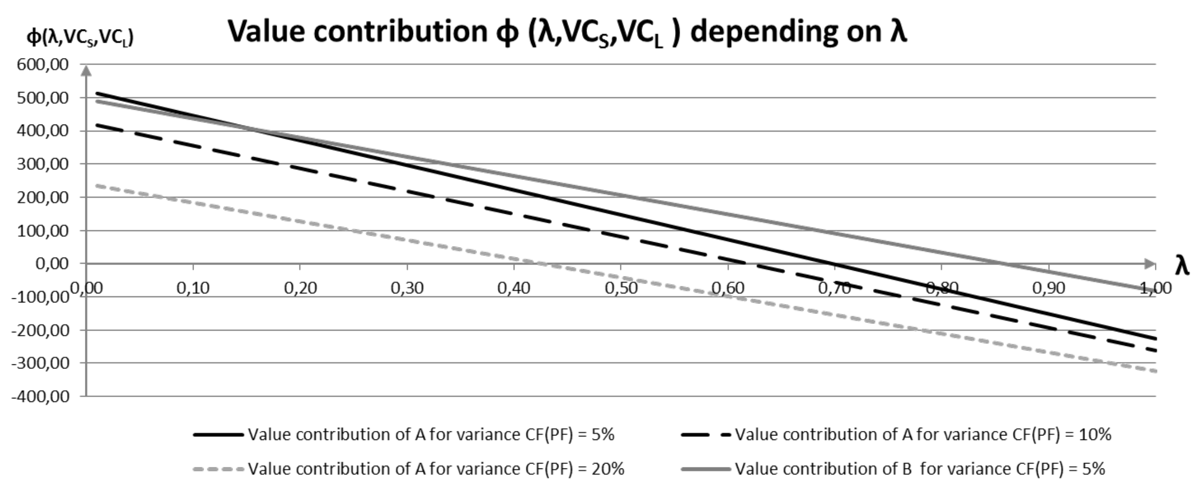

Figure III.3: Sensitivity analysis regarding the IT innovation A depending on the weighting parameter λ.

As outlined in Figure III.3, the value contribution of both investment A and B declines with an increase in λ for every considered risk position of the IT portfolio ($\sigma^2\left(\widetilde{cf}_t^{PF}\right) = 5\%; 10\%; 20\%$). Regarding IT innovation A, the more short-term oriented a decision maker is the less favorable he will value this investment which is reasonable since the IT innovation A and IMDBS as main technology in the short-term comes along with substantial investments, high interdependencies and quite uncertain long-term value contribution. Furthermore the sensitivity analysis shows that a higher risk position of the existing IT portfolio leads to a lower value contribution of investment A. The investment in the IMDBS is only favorable compared to the RDBS solution in a setting where the IT portfolio's risk is rather low ($\sigma^2\left(\widetilde{cf}_t^{PF}\right) = 5\%$) and the company takes a very long-term oriented perspective ($\lambda < 0.15$) as can be seen where the black drawn through line lies above the grey drawn through line. This scenario assumes the IT portfolio's risk to be very low which in reality can be compared to situations in which all existing IT projects, applications, processes but also business processes in other corporate units (e.g., marketing, sales) etc. run very stable and allow for integrating an immature technology like IMDBS easily without producing too much interrelations. From an analytical point of view this is reasoned by the fact that a higher stand-alone risk of the IT portfolio also increases the covariance-risk of investment A. For the case of a rather risky IT portfolio ($\sigma^2\left(\widetilde{cf}_t^{PF}\right) = 20\%$), IT innovation A by itself is still favorable (i.e., it creates a positive value contribution and assuming there is no alternative investment B) as long as the company takes a rather long-term perspective ($\lambda < 0.43$) as shown by the dotted grey line. In case of a company is taking a very short-term view ($\lambda > 0.86$) no alternative would be selected regardless of the IT portfolio setting even for a rather low risk for the existing IT portfolio ($\sigma^2\left(\widetilde{cf}_t^{PF}\right) = 5\%$). Thus, companies should always take into account the risk position and thus the stability of existing processes and applications within an IT portfolio and beyond when deciding about new IT innovation investments which are rather risky. In particular, companies might value risky IT innovation investment less/more favorable, if an existing IT portfolio runs unstable/stable and bears high/ low risks.

III.1.5 Conclusion

Though most companies know about the strategic and long-term value of IT innovation investments for gaining a competitive advantage or provide rule-changing innovations, this view often enough has to side step a short-term oriented profitability and reporting mentality within decision processes. In order to combine the different demands, this paper aims on an integrated long- and short-term approach for the valuation of IT innovation investments. As a basis for practical approaches, well-grounded methods that deliver reasonable results are required even though their application might not be possible in practice without adjustments. An object for future research will be an applicable but still methodically sophisticated business oriented method on the basis of the results presented in this paper. Apart from the problem of estimating the required input parameters (e.g., the cash flows of an IT innovation investment), another limitation of the approach is the usage of correlations, as they only represent linear stochastic interdependencies and also are difficult to estimate. Additionally, we do not consider flexibility which is another characteristic of IT innovation investments and only in a limited manner consider the implications on other business unit's innovation activities. For this purpose, companies require additional valuation approaches which might base on real option theory (e.g., IT innovation as an option for later activities in marketing or logistics). Further research is also required for the valuation and selection of those IT innovations that promise to have the most impact. Despite these potentials for improvement, the valuation approach presented within this paper constitutes a valuable extension of existing approaches by integrating the long- and short-term impact of IT innovation investments while simultaneously accounting for risks and interdependencies with regard to the existing IT portfolio. A sensitivity analysis provides first implications for research and practice regarding the impact of the IT innovation's risk, correlation to the IT portfolio, latter's risk and the decision maker's weighting of short- and long-term impacts.

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III.2 Research Paper 3: "Using IT Fashion Investments to optimize an IT Innovation Portfolio's Risk and Return"

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Abstract:

IT Fashions are new emerging IT innovations that are going through a hyped phase. Consequently they are on the rise and by their proponents claimed to be a fundamental improvement offering solutions to real or perceived problems with IT. Naturally, IT Fashions are characterized by both, high risk and high expected returns. Hitherto, suitable methodologies to quantify the impacts of IT Fashions are virtually absent. Decisions on an IT Fashion engagement (ITFE) are often made following a gut feeling or jumping on the bandwagon. Research within this area provides mainly empirical or argumentative results emphasizing the importance of academic engagement in IT Fashions. To support business decision on IT innovations and to demonstrate the importance of steady ITFE within an IT innovation portfolio, this paper aims on a model that provides the optimal share of ITFE within an IT innovation portfolio under risk/return aspects. Through a real world example from the financial industry, we obtain first results and recommendations for the role of ITFE within an IT innovation portfolio. We find that the engagement in risky IT Fashions cannot only be used to maximize the value of an IT innovation portfolio but even to minimize its overall risk..

III.2.1 Introduction

Due to the dynamic development of information technology (IT) as well as increasing competition and customer expectations, companies regularly face the challenge to decide whether to adopt new emerging IT innovations. Recent findings reveal that the most innovative companies in the technological sector invest about 15% of their innovation budget in transformational innovations that aim on breakthrough technologies and ideas which nearly make up for 85% of the returns (Nagji & Tuff, 2012). Thereby, companies never know whether an emerging IT innovation is the "next big thing" with long-term success or just a short-term hype that sooner or later fades away. To name a few examples, buzzwords like Cloud Computing, (3D) Media Tablets, Near Field Communication (NFC) or Augmented Reality are some of the topics that for now are extensively hyped both within research and practice (Gartner, 2012; Pring et al, 2009). For example, Cloud Computing applications are predicted to reach a volume of over 150 billion dollar in 2013 even though broad institutionalized is unclear yet (Pring et al., 2009; Weinhardt et al., 2009). Nonetheless, Fujitsu, one of world's largest IT management service companies invested over one billion dollar, a quarter of Fujitus's annual capital spending, in Cloud Computing (Fujitsu, 2011). Why do companies "[…] deviate from the pursuit of performance and adopt risky innovations without judicious implementation and thorough assimilation?" (Wang, 2010, p.82). The list of new technologies not fulfilling its high expectations or the dot-com bubble should be enough warning not to engage with risky IT innovations mindlessly (Fenn & Raskino, 2008).

Literature like Wang (2010), Baskerville and Myers (2009), or Fichman (2004b) define such an IT innovation within a hyped phase before it reaches broader acceptance and institutionalization as an *IT fashion*. From a research perspective, IT fashions are seen both, as a necessity in the innovation diffusion process as well as a hazard (Myers et al., 2010).

Questions like how to evaluate or when and in which extent to engage in IT fashions are major challenges for an IT innovation portfolio strategy (Dos Santos & Peffers, 1995; Wang, 2010). Thereby, an IT fashion's hype always needs to be compared appropriately against potential risks (Fenn & Raskino, 2008; Swanson & Ramiller, 2004). Even though the adoption of fashionable IT innovations can lead to higher returns due to competitive and first mover advantages, not all companies are able or willing to consider and manage the risks adequately and thus neglect a balanced view within the decision process (Fiol & O'Connor, 2003; Swanson & Ramiller, 2004; Wang, 2010). To prevent decisions on an IT fashion engagement (ITFE) in the course of a bandwagon effect, well-founded analytical models for the analysis of ITFE are necessary (Fichman, 2004b).

As ITFE often enough heavily affect business processes, investing in a losing technology can be a major threat for companies (Fenn & Raskino, 2008). However, to guarantee long-term competitive advantages, the IT strategy should consider ITFE not merely as a flash in the pan but rather as a persistent share of the corporate innovation strategy (Ross & Beath, 2002; Stratopoulos & Lim, 2010).

The objective of this paper is to transfer the central findings and ideas of portfolio and decision theory to IT fashion investments within a company's IT innovation portfolio. The application of established principles like portfolio and decision theory on new emerging IS research phenomena like IT fashion thereby bears the chance of both, opening up new research streams (e.g., analytical research regarding IT fashions) as well as revisiting a well-established methodology in research and practice (portfolio/decision theory) within a new area. We therefore aim on contributing to an IS research discourse regarding fashion waves in research and practice (Baskerville & Myers, 2009; Gill & Bhattacherjee, 2009; Myers et al., 2010).

Our research questions are the following:

RQ 1. What is the impact of an engagement in risky IT fashions on

- ***a) an IT innovation portfolio's risk?***
- ***b) an IT innovation portfolio's value regarding risk and return?***

RQ 2. What is the optimal share of ITFE within an IT innovation portfolio under risk/return aspects?

The paper is organized as follows: First, we bring our research topic into line with the current research debate, describe the idiosyncrasies of ITFE more in detail and give an overview on relevant literature. Hereafter, we bring together both academic and practical findings and combine the central aspects of Markowitz portfolio and decision theory within an integrated risk/return model from the perspective of an IT innovation portfolio. We first show that the engagement in risky IT fashions can improve both, the IT innovation portfolio's risk structure as well as its value. After discussing the results by means of a real world example and analyzing central parameters, we consolidate and discuss our findings and provide an overview of research opportunities within this area.

III.2.2 Problem Context and Related Work

Characteristics of fashionable IT innovations

Whereas traditional IT innovation research focuses on a phase in which an IT innovation has already been widely accepted (=mature IT innovation), IT fashion research concentrates on IT innovations during their very early and middle phases of diffusion in which the "[…] legitimacy stems from fashion, regardless of what the destiny of the innovation eventually turns out to be." (Wang, 2010, p.82) (=fashionable IT innovation). Both, the discourse as well as the actual adoption of IT innovations often is accompanied by fashion waves (Abrahamson & Fairchild, 1999). These waves often follow a lifecycle similar to the concept of technology adoption cycles that were originally sketched by Rogers (2003) and extended into "Hype Cycles" by the firm Gartner (Fenn & Raskino, 2008). This concept illustrates the start of an IT innovation's lifecycle by means of a *technology trigger* and excessive publicity leading to over-enthusiasm and investment decisions on the basis of bandwagon behavior. The hype usually reaches a peak of *inflated expectations* before it fades away in a *trough of disillusionment*. These three milestones mark the phase when an IT innovation has fashionable aspects. After this phase, opportunistic adopters often abandon ship, IT projects are scaled back and fashionable IT innovations might get stranded. Only few technologies are worth continuing experimenting with and putting in solid hard work in order to understand the technology's applicability, its risks, and its benefits leading to a *slope of enlightenment* for the technology which is followed by a *plateau of productivity* (Fenn & Raskino, 2008).

Hence, IT fashions need to be distinguished from other risky IT innovations where the main risk is sourced in technological challenges regarding integration, interfaces, stability or missing experts. Of course, IT fashions might come along with the same challenges during implementation. However, investments in fashionable IT innovations are additionally associated with the risk of investing in a losing technology that will never be institutionalized and thus might even lead to zero cash flows. Additionally, the company might be stuck with odd technology which once was in fashion but later has no productive use anymore while another technology prevailed. Next to this risk of non-institutionalization, IT fashions are characterized by high immaturity and a lack of thorough understanding or best practices what impedes well-founded comprehension, adoption, implementation and assimilation. Thus, the benefits (i.e., cash-flows that are associated with an ITFE) are much more difficult to estimate properly making both, required up-front investments as well as potential returns highly volatile. Also, dependencies to the development of other technologies need to be incorporated as the hype around certain technologies which is triggered by a fashion-setting-network might either push a technology even though a recession (as happened during the dot-com crisis with concepts like virtual worlds) might limit all other technological advances or a trend like mobile payment might fade away (making different types of mobile payment related technologies useless). Vice versa, even though a company usually is very successful in technology comprehension, adoption, implementation, and assimilation, the hype around a technology might just turn out to be a transient fad instead of a long-term business model. Hence, correlations might either make ITFE even more risky or allow for certain risk diversification. This makes IT fashions coming along with another type and usually higher degree of risk (Wang, 2010) which also might affect other technologies within an IT innovation portfolio.

In what follows, we show that previous literature tends to neglect these idiosyncrasies and why IT fashion research is a valuable contribution to (IT) innovation literature.

IT innovation literature

Swanson (1994, p.1072) defines IT innovation investments as the "[…] organizational application of digital computer and communications technologies (now commonly known as information technology)". Most research thereby is focusing on the question, how companies can become innovative by developing their innovator profile, i.e., their ability to adopt IT innovations successfully due to their size, structure, knowledge, or IT compatibility (Fichman, 2004a; Grover et al., 1997; Iacovou et al., 1995). This often leads to the so called *pro-innovation bias* (Kimberly, 1981) which assumes innovations per se to be beneficial and consequently values just more innovation as better. Even though the adoption of IT innovations seems to be essential to a company's long-term health (Clark & Guy, 1998; Nadler & Tushman, 1999), the exclusive investigation of positive impacts seems not adequate. Swanson and Ramiller (2004) as well as Fiol and O'Connor (2003) argue that companies should innovate mindfully, consider different types of IT innovations and implement a well-founded decision process. Thus, the conventional approach of how much IT innovation should be adopted is extended by questions like whether, when and to which extent to adopt new IT (Swanson & Ramiller, 2004). Haner (2002) claims that quality and a thorough selection of suitable types of (IT) innovations dominates the quantity of (IT) innovation as a determinant for positive returns. Other authors emphasize the probability of adoption and diffusion of a particular class of IT innovations (Rai & Bajwa, 1997; Rai et al., 2009). Fichman (2003) emphasizes considering an IT innovation's expected destiny adequately. By destiny he means that some IT innovations reach institutionalization whereas some are completely abandoned by companies.

IT fashion literature

To justify a separate IT fashion research, Fichman (2004b) and Wang (2010) offer arguments that distinguish IT fashions from management fashions even though in practice, fashionable IT innovations often have administrative components and vice versa. In contrast to management fashion, IT fashions often come along with high switching costs when restructuring the IT infrastructure or have tangible artifacts like software and hardware whereby management fashion skills often can be used in several scenarios. Lee and Collar (2003) found that IT fashions occur more frequently than management fashions what requires separate attention. Newell et al. (1998) as well as Westrup (2002) argue that the successful diffusion of certain IT innovations not only is to explain through its simplicity in implementation or its productivity increase but also through the propagation through a "fashion setting network" of consultants, vendors and academics. Companies thus often adopt IT fashions in the course of an action that is often negatively depicted as "bandwagon effect" (Abrahamson, 1991; Wang, 2010). Other authors examined the literature discourse around specific IT innovations or concepts like convergence (Herzhoff, 2010), Knowledge Management (Swan et al., 1999) or Healthcare 2.0 (Kühne et al., 2011) and conclude that most IT innovations undergo a fashionable phase before they become institutionalized and widely accepted. Regarding ITFE, Dos Santos and Pfeffers (1995) demonstrated that the very early engagement in new IT can add over proportional value. Wang (2010) found that companies that were investing in IT fashion have better reputation and improved performance due to over proportional returns resulting from competitive advantages in the long term (Wang, 2010). Still, previous IT fashion research mainly focused on fashion waves without examining the role of risk adequately or providing estimations about the right quantity of ITFE. However, the consideration of risk is crucial in this context as an ITFE either can "[…] fail to produce expected benefits, or indeed, any benefits at all." (Fichman, 2004b, p.343). As one of the few, Kauffman and Li (2005) or Häckel et al. (2013) address this challenge. Kauffman and Li (2005) apply a real options approach and argue that technology adopters are better off deferring investments until the technology's probability of becoming widely accepted reaches a critical threshold of ~60%. Häckel et al. (2013) examine the error that occurs from fixed strategies regarding the investment in fashionable IT innovations but do not explicitly incorporate risk or correlations with other technologies.

To contribute to existing literature, we apply existing and in research widely accepted methodologies (portfolio and decision theory) on a new stream of research (IT fashions) to quantify the optimal amount ITFE and examine its impact on the IT innovation portfolio's risk and return.

III.2.3 The Model

(IT) portfolio theory and the engagement in IT fashions

Financial theory and practice widely accept that that building a portfolio of several risky financial assets can outperform investments in one single risky asset even in case one single risky asset promises the highest expected return. It also can be shown that dependencies between assets and their weights in a portfolio can even result in a lower total portfolio risk compared to the lowest risk of all individual assets in a portfolio. Hence, investing solely in the asset with the lowest risk by far does not constitute for the lowest portfolio risk. This “risk diversification” effect which occurs when assets are not perfectly positively correlated can enhance a portfolio’s its risk/return position instead of “putting all eggs in one basket” (Markowitz, 1952). This idea also has been proposed to be applied for IT project portfolios (Fogelström et al., 2010; Kaplan, 2005; McFarlan, 1981; Oh et al., 2007; Santhanam & Kyparisis, 1996). Still, some research argues that financial portfolio theory might not be applicable for IT investments due to illiquidity or missing marketability (Kersten & Verhoef, 2003). This basic critique seems appropriate but does not comprise this paper’s problem context as we yield on determining the optimal share of ITFE that is by nature conducted before the investment converts into a tangible and therefore illiquid artifact (e.g., software artifact). Before the investment, the projects are still liquid assets whereas each possible combination of ITFE and non-ITFE (normal IT innovations) is characterized by its particular risk and return structure. Though IT investments cannot be cut arbitrarily (as assumed for financial portfolio theory), they often enough are conducted in sequential stages (e.g., functional blocks) and therefore can be cut along these modules (Zimmermann et al., 2008).

Financial portfolio theory as an example of explanatory design theory (Baskerville & Pries-Heje, 2010) is suitable to describe and demonstrate mathematically the idiosyncrasies of risky ITFE within an IT innovation portfolio comparable to a company that aims on building a portfolio of riskier investments (ITFE) and less risky investments, non-ITFE. Nagji and Tuff (2012) show the practical utility of a portfolio approach for managing (IT) innovations by differentiating between core innovations (to optimize existing products for existing customers), adjacent innovations (to expand from existing business) and transformational innovations (to develop breakthrough ideas for markets that do not yet exist) within an innovation portfolio. On average, they find a 70%-20%-10% ratio (core-adjacent-transformational) within the high performing companies and outline an inverse distribution of returns resulting from the innovations. For technology firms, their finding is a 45%-40%-15% ratio. Even though the findings of Nagji and Tuff (2012) do not allow for decision making processes, their findings show the practical relevance of approaching this challenge from an IT innovation portfolio perspective. As describing financial portfolio theory in the context of IT thereby has been discussed thoroughly in recent decades, the key contribution of this research is to discuss a novel and cutting-edge topic in IS innovation research (IT fashions) from an analytical point of view. Our aim is i) to extend existing IT fashion literature that hitherto mainly focused on an empirical and descriptive view on IT fashions and ii) to go beyond the academic discourse by providing a tool that can be a first step for practitioners to deal with the IT fashion phenomenon. Such analytical models are necessary to support the decision making process concerning ITFE as “IS academics should be more proactively engaged […] in the evaluation of IS fashions” (Baskerville & Myers, 2009, p.648). Though theoretical models in a first step often seem to be too complex to be implemented in practice, dealing with the fashion phenomenon needs methodological rigor models that deliver reasonable results even though they might not be applicable without adjustments. Though IT fashion theory thereof has to abstract from reality in a reasonable manner to reduce complexity, this “[…] does not make theory un-useful, or impossible” (Myers et al., 2010, p.4).

In the following, we present an optimization model that is based on portfolio and decision theory and determines the optimal share of ITFE within a budget dedicated to an IT innovation portfolio regarding both, risk and return. Our central contribution to IT innovation literature thereby is the integration of risk and return into an analytical optimization model that values a certain type of IT innovations, namely ITFE, from an IT innovation portfolio point of view. In a first step, we describe the general setting and the parameters for the application of portfolio theory. We show that even with a risk minimizing strategy that tries to avoid risky investments, even riskier ITFEs can oftentimes be justified. This is due to their risk diversification effect even if in the first place, a risk-averse laggard strategy could be assumed just to set the ITFE share to zero. In a second step, we go beyond portfolio theory by applying decision theory and show that an integrated view on risk and return justifies a steady stream of ITFE even more than a purely risk reducing laggard strategy. Therefore, we first need some definitions and simplifying assumptions for the relevant parameters.

Definitions, assumptions, and operationalization of ITFE characteristics

Our analysis' focus is on a company's that decides how much to invest into ITFE (fashionable IT innovation) and non-ITFE (normal IT innovations). The investment opportunities are clustered in these two major categories according to their discourse, diffusion, popularity and maturity (Häckel et al., 2013; Tsui et al., 2009; Wang, 2009). Determining the value of the parameters that we are going to use within our model is not a trivial task. Though we in the following provide some indications how determine the values for the model parameter, we generally assume the existence of such aggregated data on a higher level and describe the model, the required assumptions and relevant parameters within the following decision setting. We consider a company planning the use of a given IT innovation budget (ITIB) for the next period (Häckel et al., 2013; Kiessling et al., 2011) and thus disregard from multi-period impacts (like a real options approach would do). The budget is not constrictive, meaning that projects will not be stopped due to expenses higher than expected or enlarged due to expenses lower than expected.

We define $x \epsilon [0,1]$ as a parameter describing the share of ITFE of the ITIB and thus as our decision variable. With $x = 1$, the company's ITIB is completely invested into ITFE generating a net present value NPV_F (including initial investments and return). With $x = 0$, ITIB is completely invested into non-ITFE (normal IT innovations) resulting in a net present value NPV_N (including initial investments and return). We consider NPV_F and NPV_N to be stochastic random variables with the distribution parameters $\mu_F > 0$, $\sigma_F > 0$ and $\mu_N > 0$, $\sigma_N > 0$ describing the respective expected values and standard deviations. NPV_F and NPV_N are correlated with $\varrho \, \epsilon \,]-1,1[$ describing their Bravais-Pearson-coefficient. Due to their different nature we omit perfectly positive ($\varrho = 1$) or perfectly negative ($\varrho = -1$) correlation between ITFE and non-ITFE. These correlations thus measure the interdependencies between ITFE and non-ITFE and thus also illustrate an idiosyncrasy of IT fashions and distinguish them from other risky IT investments as IT fashions often are object of (irrational) rumor and promoted by a fashion-setting-network, regardless of whether the market develops similar. Even in crisis where companies only realize low or even no value from other technologies, the hype around a technology can make it out-perform the market and vice versa. As ITFE are assumed to have a positive impact on a company's performance (Wang, 2010), we furthermore suppose $\mu_F > \mu_N$. Thus, we operationalize very important idiosyncrasies of fashionable IT innovations within our model by incorporating the correlation as well as the superior return potential. Even though ITFE might be associated with higher returns, risk has to be considered thoroughly as described above. To operationalize the main characteristic that distinguishes ITFE from investments in other risky IT investments, our model focusses on the risk that comes along with an ITFE. First, this risk emerges from the potential non-institutionalization (as described above) which leads to the threat of investing in a technology with no potential, no returns (i.e., positive cash flows) and thus all in all even negative cash flows due to a high initial investment. Second, a lack of experience and best practices, the rumor spread by the fashion-setting-network and thus difficult estimations about the real potential make the estimations of an ITFE's cash flows (both, for costs and benefits) highly volatile and difficult.

Hence, next to this risk associated with the market, risks concerning the technology itself also influence the extent of the expected return's volatility. Even in case the technology becomes institutionalized, the implementation of the former fashionable technology that comes along with changing and adjusting processes and strategies, system developments, business-alignment, reaching productivity and acceptance is rather difficult as experiences or best practices are rarer than when a more mature technology is adopted.

Due to the above illustrated risk of ITFE in contrast to non-ITFE, we operationalize a main characteristic of ITFE and suppose $\sigma_F > \sigma_N$. In our model, the company measures its return by expected net present values and its risk by variances. Although variances feature upside and downside risk, this risk measure is commonly used in financial theory and it has also been applied on IS literature by various other authors in the context of IT portfolio management (Fridgen & Müller, 2009; Zimmermann et al., 2008). One could argue that measuring upside potential as a risk is not intuitive. Of course, using variances in this paper in a first view might be simplifying matters, but in the context of an ex ante evaluation of ITFE also is very useful. We thereby operationalize another key idiosyncrasy of ITFE which, at the time of investment, bear both the chance of becoming institutionalized (upside "risk") and the possibility of ending as a losing technology (downside risk). An ex ante decision support model thereby aims on both, sanctioning the underestimation of investing in a losing technology as well as sanctioning the underestimation of the upside potential which can result in not being prepared adequately for the success (lack of capacity, service level agreements, client counselors etc.). Moreover, our general results also hold true for pure downside risk measures like Value-at-Risk or Lower-Partial Moments.

If the company chooses to invest into ITFE, then the ITFE's minimal share of ITIB is given by $\underline{x}$ with $0 \leq \underline{x} \leq 1$. If the company decides to invest into non-ITFE, then the ITFE's maximal share of ITIB is given by $\overline{x}$ with $0 \leq \overline{x} \leq 1$. With $\overline{x} < \underline{x}$, an investment into ITFE would forbid an investment into non-ITFE and vice versa, so in the following we presume $\underline{x} < \overline{x}$. These lower and upper bounds can be interpreted as minimal project sizes for ITFE and non-ITFE meaning that if a company decides to realize ITFEs, it needs a minimum engagement to realize a significant outcome. In terms of real options, a minimum requirement can also be interpreted as the minimal module that is required to enable a later extension or that an investment below the minimum bound still might be useful to keep the (real) option of a later entry. On the other hand, *if* a company decides to realize non-ITFEs, it also needs a minimum of engagement in non-ITFE (=maximum of ITFE). Respectively, we simplify from considering discrete projects in more detail by the following assumption 1.

Assumption 1: *Within $[\underline{x}, \overline{x}]$ any x can be realized.*

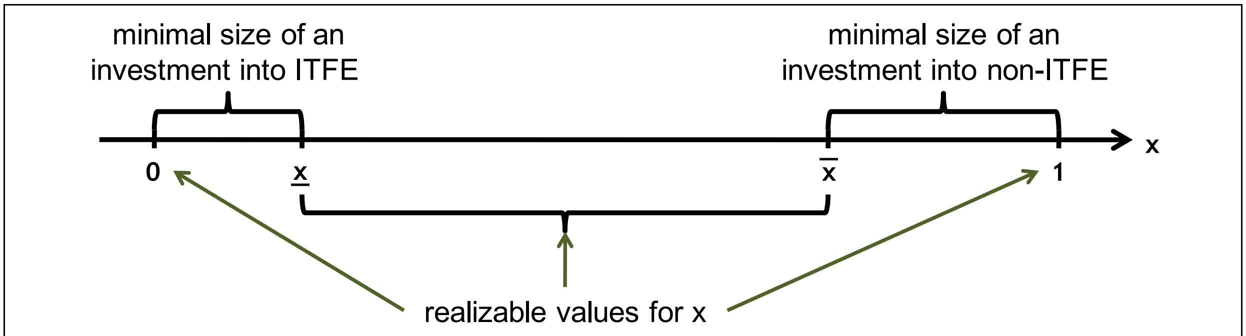

Figure III.4: Realizable values of the optimal share of ITFE within an IT innovation portfolio.

Assumption 1 can be justified by recent developments in computing concepts like service oriented architectures, which enable high scalability of IT projects. Combining several ITFE furthermore allows for investments of many different sizes. Therefore, we consider assumption 1 to be a reasonable simplification. This scalability and the fact that IT investments usually are conducted in sequential stages ensure that our model considers the necessity of infinitely divisible assets within financial portfolio theory. To consider the fact that IT investments are not infinitely divisible, one would evaluate the adjacent realizable module selections and choose the one that features a better value in the objective function. To determine the expected values and standard deviations of NPV_F and NPV_N for different x we moreover need the following simplifying assumption 2:

Assumption 2: *The share x of the ITIB is directly proportional to the expected net present value of the ITFE μ_F. The share $1-x$ of the ITIB is directly proportional to the expected net present value of the non-ITFE μ_N. Every fraction of NPV_F is perfectly correlated to every other fraction of NPV_F. Equally sized fractions of NPV_F feature the same standard deviations. Every fraction of NPV_N is perfectly correlated to every other fraction of NPV_N. Equally sized fractions of NPV_N feature the same standard deviations.*

By assuming perfect correlations within NPV_F and NPV_N, but a distinct correlation between NPV_F and NPV_N, we implicitly assume that ITFE and non-ITFE can be specifically distinguished regarding their risk, return and interdependencies. This is obviously simplifying matters, as different projects within the ITFE (or non-ITFE) part of the ITIB may carry different risk. Nevertheless, as stated above, a differentiation between projects partially was examined by Wang (2010), goes beyond the scope of this paper, and still is subject to further research in this area. Our real world example furthermore shows that there are practical settings that allow for this simplification.

As a consequence of assumption 2, we can state that the distribution parameters of $xNPV_F$ are $x\mu_F$, $x\sigma_F$ and that the distribution parameters of $(1-x)NPV_N$ are $(1-x)\mu_N$, $(1-x)\sigma_N$.

Why minimizing risk does not mean avoiding ITFE

One could assume that a risk minimizing strategy concerning ITFE is equivalent with a strategy that aims on being an innovation laggard that does not engage in a new emerging technology more than what is absolutely necessary. Regarding our model, one intuitively would set x=0. As our paper yields on demonstrating the usefulness of a steady and significant engagement in new emerging technology in their fashionable phase, we in the following formally show that a risk minimizing investment strategy, i.e. an innovation laggard strategy, often enough results in values of x>0. Consequently, even ITFEs on an experimental level can make sense as from a real options perspective they can allow later entries into emerging technologies at a later point in time. Under the given assumptions, investing a share x of the ITIB into ITFE results in a portfolio return and risk as described in the following:

$$\mu_{PF} = x\mu_F + (1-x)\mu_N$$
$$\sigma_{PF}^2 = x^2\sigma_F^2 + (1-x)^2\sigma_N^2 + 2\varrho \cdot x\sigma_F \cdot (1-x)\sigma_N$$

To minimize the risk associated with the company's ITIB, we set the first derivative of σ_{PF}^2 with respect to x equal to 0. By solving this term for x we get a candidate $\breve{x}$ for risk minimization.

$$\frac{\delta\sigma_{PF}^2}{\delta x} = 2x\sigma_F^2 - 2\sigma_N^2 + 2x\sigma_N^2 + 2(1-2x)\cdot\varrho\sigma_F\sigma_N = 0$$
$$\breve{x} = \frac{\sigma_N^2 - \varrho\sigma_F\sigma_N}{\sigma_F^2 + \sigma_N^2 - 2\varrho\sigma_F\sigma_N}$$

Under the given assumptions it is easy to show that $\frac{\delta^2\sigma_{PF}^2}{\delta x^2} > 0$ holds true. Therefore, the portfolio risk σ_{PF}^2 is strictly convex with x. $\breve{x}$ thus minimizes the portfolio risk for $\breve{x} \in [\underline{x}, \overline{x}]$. To satisfy assumption 1 and our rules regarding the lower and upper bounds, the optimal share of the ITIB x^* from a portfolio risk minimization strategy theoretically is described as follows:

$$x^* = \begin{cases} \underline{x}, if\ \breve{x} < \underline{x}\ and\ \sigma_{PF}^2(0) > \sigma_{PF}^2(\underline{x}) \\ 0, if\ \breve{x} < \underline{x}\ and\ \sigma_{PF}^2(0) \leq \sigma_{PF}^2(\underline{x}) \\ \boldsymbol{\hat{x}, if\ \hat{x} \in [\underline{x}, \overline{x}]} \\ \overline{x}, if\ \breve{x} > \overline{x}\ and\ \sigma_{PF}^2(1) \geq \sigma_{PF}^2(\overline{x}) \\ 1, if\ \breve{x} > \overline{x}\ and\ \sigma_{PF}^2(1) < \sigma_{PF}^2(\overline{x}), \end{cases}$$

Analyzing $\breve{x}$, we find that $\breve{x} < 1$, if $\sigma_F > \varrho\sigma_N$ which is always true under our assumptions. Moreover, $\breve{x} > 0$, if $\sigma_N > \varrho\sigma_F$. Consequently, for a negative correlation or for uncorrelated ITFE and non-ITFE ($\varrho \leq 0$), $\breve{x}$ is always positive. Furthermore, in reality we would expect σ_F and σ_N to be of a similar magnitude whereas ITFE and non-ITFE are probably not strongly positively correlated. For example, $\varrho = 0.2$ would require $\sigma_F > \mathbf{5}\sigma_N$ for $\breve{x}$ becoming negative. This can be argued by the fact that a fashionable IT innovation often enough replaces an existing technology in case it becomes institutionalized. Therefore, even with a risk minimizing strategy, riskier ITFEs can oftentimes be justified due to their risk diversification effect, at least if the candidate for risk minimization $\breve{x}$ exceeds the minimal size for an investment into ITFE $\underline{x}$.

As companies usually do not limit themselves to minimizing risk but rather try to achieve an integrated optimization of risk *and* return we in the following section go beyond basic portfolio theory and extend our model in this direction.

Why maximizing an IT innovation portfolio's value requires ITFE

For an integrated optimization of risk and return with the decision on the ITIB, we first need an assumption on the compensation of risk by return.

Assumption 3: The company maximizes the objective function $\Phi = \mu_{PF} - \alpha\sigma_{PF}^2$. The company is risk-averse.

This objective function is a preference function that is in accordance to established methods of decision theory and integrates the expected portfolio net present value, its variance, and the decision maker's risk aversion. Assuming NPV_F and NPV_N to be normally distributed, and assuming the decision maker to have an exponential utility function $U(x) = -e^{-2\alpha x}$, it is furthermore compatible to the Bernoulli principle (Bernoulli, 1954) and thus can be interpreted as a certainty equivalent. Its Arrow-Pratt characterization of absolute risk aversion (Arrow, 1971) is 2α with $\alpha > 0$ modeling a risk-averse decision maker. As a key characteristic of ITFE is their substantially high risk in contrast to other IT investments, one could interpret the parameter of risk aversion α as an indicator of aversion to fashionable IT innovations and thus judge ITFE as unattractive for a risk-averse decision maker. Despite the fact that a risk-averse decision maker indeed might be less sensitive to bandwagon-effects and rumor that is spread from fashion-setting-networks, we will show that an ITFE makes sense for risk-averse decision makers both, for minimizing an IT portfolio's risk as well as for maximizing its value. Assuming normally distributed net present values is surely simplifying matters but reasonable for a large numbers of IT projects within an ITIB and on the background of the central limit theorem and generalizations thereof (see especially Withers, 1981). The assumption of decision makers or companies with constant risk aversion thereby is in line with Friend and Blume (1975). The higher the value of α, the more risk-averse the company is (Friend & Blume, 1975; Longley-Cook, 1998). Similar formal approaches and assumptions for risk adjusted economic value analysis have been derived by Longley-Cook (1998) and have been applied in the context of IT portfolios numerous times, for example in Fridgen and Müller (2009), Bardhan et al. (2004), Zimmermann et al. (2008) and Hanink (1985).

The objective function for the described problem that is to maximize thereby is from the following form:

$$\Phi = x\mu_F + (1-x)\mu_N - \alpha(x^2\sigma_F^2 + (1-x)^2\sigma_N^2 + 2\varrho \cdot x\sigma_F \cdot (1-x)\sigma_N) \rightarrow max!$$

To maximize the objective function with the company's ITIB, we set the first derivative of Φ with respect to x equal to 0. By solving this term for x we get a candidate $\hat{x}$ for optimality.

$$\frac{\delta\Phi}{\delta x} = \mu_F - \mu_N - \alpha \cdot (2x\sigma_F^2 - 2\sigma_N^2 + 2x\sigma_N^2 + 2(1-2x) \cdot \varrho\sigma_F\sigma_N) = 0$$

$$\hat{x} = \frac{\mu_F - \mu_N + 2\alpha(\sigma_N^2 - \varrho\sigma_F\sigma_N)}{2\alpha(\sigma_F^2 + \sigma_N^2 - 2\varrho\sigma_F\sigma_N)}$$

Again, it is easy to show that $\frac{\delta^2\Phi}{\delta x^2} < 0$ holds true under the given assumptions. Therefore, the objective function is strictly concave with x. The optimal share of the

ITIB x^* when applying a portfolio value optimization strategy theoretically is described as follows:

$$x^* = \begin{cases} 0, if\ \hat{x} < \underline{x}\ and\ \Phi(0) > \Phi(\underline{x}) \\ \underline{x}, if\ \hat{x} < \underline{x}\ and\ \Phi(0) \leq \Phi(\underline{x}) \\ \boldsymbol{\hat{x}, if\ \hat{x} \in [\underline{x}, \overline{x}]} \\ \overline{x}, if\ \hat{x} > \overline{x}\ and\ \Phi(1) \leq \Phi(\overline{x}\ ) \\ 1, if\ \hat{x} > \overline{x}\ and\ \Phi(1) > \Phi(\overline{x}\ ) \end{cases}$$

Analyzing $\hat{x}$, we find that $\hat{x} > \breve{x}$, i.e. that the ITIB's share that is invested into ITFE is higher in case of a portfolio optimization strategy than in a pure a risk minimizing strategy. Therefore, portfolio optimization justifies investments into ITFE even more than a risk minimizing strategy. All together, we in a theoretical manner demonstrated that riskier ITFEs can oftentimes be justified as they can have a positive impact on an IT innovation portfolio's risk. Additionally, we showed that ITFEs also positively influence an IT innovation portfolio's value regarding risk and return. To find the optimal share of ITFE within an IT innovation portfolio under risk/return aspects, we developed a model that is based on portfolio and decision theory which provides this optimal share. Hence, we provided theoretical answers for both research questions RQ 1 and RQ 2.

In the following, we present a "proof of concept" of the optimization model's practical applicability that is based on our own experience from a current industry project at in the financial service industry. As IT fashion literature is a very young discipline, it is virtually impossible to acquire real world data set to test the model with input from practical data. However, as the next paragraph shows, applying the model can lead to considerable advantages. According to Hevner et al.'s (2004) design science approach, an analytical evaluation through a real world example is legitimate though descriptive methods in evaluation "[…] should only be used for especially innovative artifacts for which other forms of evaluation may not be feasible" (Hevner et al., 2004, p.86). In addition, we base the real world example on our experience from a parallel running international industry project in the financial service industry and apply fictive values that illustrate the decision setting realistically. Within this related research project, we personally interviewed over 20 top executives and sent a survey to over

1,000 industry experts from research and practice to gain insights into their innovation strategies and estimations about future developments regarding the engagement in more or less fashionable technologies in the financial service industry. Deriving adequate values and data for this kind of research from existing data sets is due to a next step in further research. As decision making processes in practice concerning usually are based on a gut feeling, we consider the combination of analytical optimization and a descriptive, numerical example as sufficient to demonstrate of our design artifact's utility, efficacy, and quality (Hevner et al., 2004).

III.2.4 Real World Example

The following example follows a real world case from an international financial service provider (FSP) that needs to decide on how to engage in one more mature technology and one more fashionable technology in the payment technology area. The FSP offers typical retail banking services like account management or payment. Due to the increasing competition of web-based banks and new competitors in the payments market, the FSP fears to lose customers as new and hip payment methods rush into the market. Various market researchers and vendors promise the end of traditional payment methods and those companies who are not engaged in new (mobile) payment methods to become extinct (A.T. Kearney, 2012). To avoid lagging behind technological developments, the FSP has to decide between two promising innovations in (mobile) payment technology that differ in terms of maturity regarding institutionalization and technical applicability.

QR (Quick Response)-Code based payment solutions: Based on a matrix barcode that is readable by mobile phones and also can be generated through mobile phones, payment data like price or account number can be transferred into code. Mobile phones by that can read payment data with an integrated camera and conduct payment through specialized software as well as realizing peer-to-peer payments by generating an own QR-code. According to the current sentiment in the market, the current Gartner Hype Cycle estimation (Gartner, 2012) and the fact that nearly every mobile phone is able to read QR-Code, this technology is on the way to institutionalization and *slope of enlightenment*. Gartner expects it to become widely adopted within 2-5 years.

NFC based payment solutions: Based on a wireless connection between two devices (e.g., two mobile phones or a payment terminal), NFC allows contactless payment by exchanging payment data across a few centimeters. In contrast to QR-Code based solutions, this technology requires a relevant infrastructure like payment terminals, NFC chips in mobile phones to be applicable but on the other hand is much more comfortable, easier to handle and bears more other features and possibilities. According to the current sentiment in the market and the current Gartner Hype Cycle estimation (Gartner, 2012), this concept can be classified as fashionable as it currently hits the *peak of inflated expectations* and is estimated to become widely accepted earliest within 5-10 years. Though only a minority of today's mobile phones is equipped with a NFC chip, NFC is expected to massively become adopted and institutionalized when relevant infrastructure and devices are available for this technology. On the other hand, the risk of investing in technology that may never become institutionalized or may take more time within ten years still exists.

Initial decision setting

For the FSP, the decision setting occurs, how much to engage in the more mature and non-ITFE (QR-Code based payments) and whether and how much to engage in an ITFE (NFC based payments) to be prepared for an eventual breakthrough of both technologies. The FSP evaluates the two options for using the next year's IT innovation budget of 5 million €:

QR-Code payment solution (non-ITFE): To adopt at least the temporary time where other technology and infrastructure it not available yet, the minimal investment (= integrate and adapt an existing solution) into QR-Code is $€\,400{,}000$ ($\overline{x} = 1 - \frac{400{,}000}{5{,}000{,}000} = 92\%$). For a full investment (=incl. marketing, own mobile application etc.) of 5 million € into this option ($x = 0$), the FSP expects a net present value (including the initial investment spending) of $\mu_N = €\,300{,}000$ and risk of $\sigma_N = €\,30{,}000$ which is a 10% standard deviation from the expected net present value and calculated as a variance of $\sigma_N^2 = €\,30{,}000^2$ within our model.

NFC payment solution (ITFE): For an initial investment into the NFC technology the FSP expects at least an investment of $€\,1.500{,}000$ ($\underline{x} = \frac{1.500{,}000}{5{,}000{,}000} = 30\%$). For a full investment of 1.5 million € into this option ($x = 1$), the FSP expects a net present value (including the spending) of $\mu_F = €\,550{,}000$ and risk of $\sigma_F\ = €\,110{,}000$ which is a 20% standard deviation from of the expected net present value, calculated as a variance of $\sigma_N^2 = €\,110{,}000^2$ within our model, and thus substantially higher than the risk of the non-ITFE.

Though we assume fictive initial values for our model evaluation, the initial values for the expected present value (μ_F; μ_N), the risk (σ_F^2, σ_N^2), and the lower and upper bound depict the different characteristics of the different IT innovations, their potential benefits, the associated risk as well as the required minimum investments quite well and so allow for demonstrating the model's usefulness for real world business decisions. To derive such values in real world, companies could make use of estimations by experts as well as internal and external historical data regarding IT innovation investments. For example, Gartner's Hype Cycle from past years can help to categorize the company's former IT innovations investments into ITFE and non-ITFE and give an overview on whether the company invested in a new emerging technology, while it was in fashion or when it already was institutionalized. Thereof, a company can gain data about each IT innovation category's returns and its deviations to derive estimators for the future. Another useful source can be derived from research companies like International Data Corporation (IDC). IDC annually interviews CIOs and other IT decision makers regarding their IT investment plans and provides exclusive categories of different types of IT investments. Using this data helps to get an overview on whether or how much was invested by competitors in the same technology with-in the same time frame. Combining both, historical internal and market data is a first step to derive estimators for the values of ITFE which are required for the application of our model. Of course, the company also can apply interviews with experts from financial management, marketing, the IT department and the top-management to estimate potential values for the values of the model application. Beer et al. (2013) exemplarily provide a methodology to estimate the benefits of IT investments which can be applied to the estimations of ITFE-benefits as well as their volatility and risk.

The two options F and N are using quite different matters to gain acceptance from the consumers. Therefore, their success might be uncorrelated as mobile payment in general, regardless of certain technologies that realize it, by far is not widely accepted yet. It also may be positively correlated in case the mobile payment in general does not experience wide adoption or another technology occurs. As the success of one technology might even decrease the success of the other one, they could even be negatively correlated. Weighing all arguments, the success of the two options is estimated to be quite independent from one another with a small positive correlation of $\varrho = 0.2$. As the success of any technology highly depends on the mobile payments overall acceptance, we consider assumption 2 to be reasonable for both options. Last, we have to determine the FSP's parameter of risk aversion α. As stated above, α gives an indication on the decision-maker's risk aversion and thus the aversion against ITFE which can be characterized by high risk. Thus, the higher the value of α, the more risk-averse the decision-maker is. Practitioners often find this concept of risk aversion to be rather abstract making a precise determination very difficult. To determine a reasonable value for α, one has to incorporate the monetary dimensions of investments and for example use a survey to determine a company's parameter of risk aversion at the executive level which is often applied in decision making and behavioral finance (Bamberg & Spremann, 1981) but also has found application in IT investment decision making (Beer et al., 2013). In the approach of Beer et al. (2013), decision makers across multiple questions have to provide information about their maximum willingness to pay for different fictive project settings to determine the risk class (e.g., fashionable IT innovation, normal IT innovation, normal IT asset investment), which is afterwards assigned to a corresponding value of risk aversion. To make our application example more realistic, we apply almost the same value $\alpha = 0.00003$ as found by Beer et al. (2013) in a real world IT investment decision.

Analyzing a risk-minimizing strategy

For $x = 0\%$ (no ITFE, i.e. no NFC investment, only QR-Code investment), we get $\Phi = € \, 273{,}000$, for $x = 100\%$ (only ITFE, i.e. only NFC investment), we get $\Phi = € \, 187{,}000$. At a first glance, the investment in QR-Code based payment solutions therefore seems more attractive. For a risk minimizing investment strategy, we find

$\breve{x} = 2.1\%$ which means that the risky ITFE would still improve the risk position of the investment portfolio even though one might expect $\breve{x} = 0\%$ to minimize the risk. On the other hand, 2.1% is below the threshold for investments into ITFE with $\underline{x} = 30\%$. Thus and in accordance to our case differentiation, the FSP will choose $x^* = 0\%$ to minimize the portfolio risk. However, if a company aims on gaining experience with NFC on an experimental level, an ITFE with $\breve{x} = 2.1\%$ from a real options perspective can make sense as it then allows easier entry later when the technology is widely accepted.

Analyzing a portfolio optimization strategy

Applying a portfolio optimization, we find $\hat{x} = x^* = 37.7\%$. This is not only within the range of $\underline{x}$ and $\overline{x}$ but also considerably increasing the objective function to $\Phi =$ € $322{,}877$. In this real world example the proposed portfolio optimization therefore not only improved the investment decision, it also justified a relevant investment into an ITFE, in this case the risky investment in NFC-based payment solutions, to stay ahead of the technological developments.

Table III.3: Results for the IT innovation portfolio's value at different innovation strategies.

IT-Innovation Strategy	Share NFC investment (x)	Share QR-Code investment (1-x)	Φ
No ITFE investment	0	1	$273{,}000$
Only ITFE investment	1	0	$187{,}000$
Risk minimizing	$\breve{x} = 2.1\% \Rightarrow x^* = 0$	1	$273{,}000$
Portfolio optimization	$x^* = 0.377$	0.622	$322{,}877$

Analyzing the influence of major input variables

To analyze how changes of the model's core parameter impact the ITFE decision making regarding portfolio risk minimization and value optimization, we in the following apply an own analysis regarding expected net present value (μ_F), risk (σ_F^2), the correlation ϱ, and the FSP's risk aversion α. For that, we always change the corresponding parameter's value and examine how the optimal ITFE changes compared to our initial setting both, for a portfolio risk minimization as well as a portfolio value optimization strategy. Within our analysis, we in particular are interested in turning points and constellations, which lead to a minimum ITFE ($\underline{x} = 0.3$).

Expected net present value (μ_F): To illustrate the impact of changes regarding μ_F, we in the following first are interested in answering the question whether an increase of μ_F also implies a higher ITFE when aiming on an optimized portfolio value. Afterwards, we examine how the optimal ITFE changes with a decreasing μ_F when applying a risk minimizing strategy. For both analyses, the tradeoff between an increased expected net present value and the associated risk of higher absolute volatility is of high interest as we generally expect the net present value to come along with a constant standard deviation of 20% from the expected net present value (which we then calculate as variance in our model).

Compared to our initial value $\mu_F = € 550{,}000$ which leads to $x^* = 0.3772$, an increase of μ_F interestingly leads to a lower optimized ITFE. This is due to the associated risk that needs to be considered. Exemplarily, a 10% increase of $\mu_F = € 605{,}000$ under our assumption leads to a 10% higher standard deviation but a substantially higher risk, measured by absolute variance in our model and thus is sanctioned with $x^* = 0.373$. The maximum ITFE is reached for $\mu_F \sim 542{,}600$ where the FSP optimizes the portfolio value with $x^* \sim 0.3773$ which is slightly higher than our initial optimum. Thus, there is an upper limit for the expected net present value that makes increased ITFE favorable to optimize the portfolio value in case the expected net present value's standard deviation which then is calculated as absolute variance stays constant.

Regarding the goal of minimizing the portfolio risk, the same 10% increase of the initial expected net present value up to $\mu_F = € 605{,}000$ decreases the ITFE from initial theoretical value $\breve{x} = 0.021$ to $\breve{x} = x^* = 0$ and thus even theoretically makes ITFE (on an experimental level) unfavorable. An ITFE which exceeds the minimum requirement of $\underline{x} = 0.3$ and simultaneously minimizes the portfolio risk can be realized for an expected net present of $\mu_F = € 210{,}000$ which simultaneously is associated with a decrease of the net present value's standard deviation of about 60%.

Risk (σ_F^2): Regarding an ITFE, decision makers in particular are interested in how much risk an IT portfolio can take while still investing the minimum amount $\underline{x} = 0.3$. Also, it is of interest up to which risk level an ITFE sill makes sense even if it is just on an experimental level or to keep a risk minimizing effect. To answer these questions, we start our analysis from our initially assumed 20% standard deviation from the expected net present value (which we then calculate as risk in terms of absolute variance in our model) and which resulted in an optimized portfolio value with $x^* = 0.377$.

First, it is noticeable that even a minor increase up to a standard deviation of ~22.3% already decreases the optimal ITFE and results in $x^* = \underline{x} = 0.3$ which we consider as the required minimum engagement. Second, to reach the risk limit where the decision maker excludes an ITFE within a portfolio optimization strategy (even on an theoretical experimental level) with $\hat{x} = 0 \Rightarrow x^* = 0$, the standard deviation would have to increase up to more than ~153% (leading to the respective risk measured by the absolute variance). This illustrates that even an extremely unrealistic risky ITFE still would create value for the FSP though these ITFE do not enable reasonable investments that require a minimum engagement to create substantial competitive advantage.

To illustrate which risk level still makes ITFE favorable from a risk-minimizing perspective (i.e., $x^* > 0$) even if it is only on an experimental level, it can be shown that a decision maker would exclude an ITFE for a standard deviation above ~27.3% (i.e., $\breve{x} = 0 \Rightarrow x^* = 0$. Below this level, an ITFE on a theoretical experimental level (which in terms of real options in future might be of relevance) still might allow for minimizing the portfolio risk (depending also on the case differentiation).

Correlation (ϱ): As an IT fashion like NFC is characterized by a hype phase without solid assessment, it might either lead to over-proportional success and institutionalization even if similar technologies like QR-Code become stranded. Also, it might end up as a losing technology even though mobile payment generally becomes the next big thing (measured through negative correlation). This constellation typically leads to a higher ITFE as this diversification effect lowers the portfolio's total risk. Thus, decision makers are interested how extreme values affect the optimal ITFE when optimizing the portfolio value or minimizing the portfolio risk. Also, it is interesting to know up to which value of ϱ, the minimum engagement still optimizes the portfolio value.

In the extreme case of $\varrho = -1$ (theoretically excluded in our model assumptions) which indicates that if QR-Code gets stranded, NFC will become the next big thing, the FSP optimizes its portfolio value with $x^* = 0.427$ and minimizes the portfolio risk with

$\breve{x} = 0.214$ which is below the minimum engagement and thus would lead to $x^* = 0.3$ according to our case differentiation and thus makes sense for the FSP. Hence, only in the very unrealistic (and theoretically also excluded) case of $\varrho = -1$, the ITFE for both strategies (portfolio value optimization and risk minimization) increases significantly compared to our initial setting.

The minimum engagement with $x^* = \underline{x} = 0.3$ will be realized for $\varrho \sim 0.8835$. This means even if NFC and QR-Code are almost positively correlated, i.e., if QR-Code becomes successful, NFC payment also develops positively (which a rather unrealistic case as usually one technology dominates the market in the payment area), still justifies a minimum engagement. In practice, this can mean that in a market that hypes mobile payment and thus more than one dominant technology exists, an FSP should focus on one technology but still offer customers another established payment technology.

Risk aversion (α): As risk aversion plays a substantial role in our model and also illustrates the decision maker's attitude towards the risk associated with ITFE, it is interesting to know how a more or less risk-averse decision maker engages in fashionable IT and how this affects the IT innovation portfolio's risk and return. In particular, we are interested in how risk-averse a decision maker can be to still invest the required minimum amount in IT fashions or how more risk affinity is required to even invest the maximum amount in an IT fashion to optimize the portfolio value. For both, a more risk-averse as well as a less risk-averse (i.e., more risk affine) decision maker, we also are interested in the tradeoff between more/less risk (i.e., increased standard deviation and thus variance) and more/less return which can be realized through ITFE. For that, we in a first step determined the risk aversion that leads to the minimum ITFE ($\underline{x} = 0.3$) and find this for a risk aversion with $\alpha = 0.000038258$. This indicates that a decision maker who is slightly more risk-averse compared to the initial risk aversion ($\alpha = 0.00003$) still invests the required minimum amount in IT fashions. This ITFE also lowers the value of the optimized portfolio by about 5% and the portfolio's risk by about 24%.

A decision maker who optimizes the portfolio value with the maximum ITFE ($\overline{x} = 0.92$) requires a risk aversion of $\alpha = 0.00001189$ which is substantially lower (i.e., less risk-averse) compared to our initial value. Though such an ITFE increases the optimized portfolio value by about 26%, it also increases the portfolio's risk by about 335% which in practice is rather an unrealistic business case.

To illustrate the tradeoff between risk and return in dependence on the risk aversion, we started our analysis from our initial value and examined how a similar increase or decrease in risk aversion affects the optimal ITFE (x^*). As a boundary, we set the lower limit around the value for the risk aversion where $x^* = \underline{x}$ (with $\alpha \sim 0.000038$). To compare different risk aversions, we examined same absolute values for increased as well as decreased risk aversion as illustrated in Table III.4.

Table III.4: Tradeoff between the risk aversion and the optimal portfolio value and risk.

	more risk-averse			**less risk-averse**	
$\boldsymbol{\alpha}$	**0.000038** $(+0.000008)$	**0.000035** $(+0.000005)$	**0.00003**	**0.000025** (-0.000005)	**0.000022** (-0.000008)
$\boldsymbol{x}$	$x^* = 30.22\%$ (-7.48%)	$x^* = 32.63\%$ (-5.07%)	$x^* = 37.7\%$	$x^* = 44.86\%$ $(+7.16\%)$	$x^* = 50.70\%$ $(+13.00\%)$
$\boldsymbol{\mu_{PF}}$	€ 375,545 (-4.76%)	€ 381,580 (-3.23%)	€ 394,321	€ 412,158 $(+4.52\%)$	€ 426,751 $(+8.22\%)$
$\boldsymbol{\sigma^2_{PF}}$	$42{,}677^2$ (-23.51%)	$44{,}577^2$ (-16.56%)	$48{,}800^2$	$55{,}095^2$ $(+27.46\%)$	$60{,}490^2$ $(+53.65\%)$

Table III.4 shows that compared to our initial value of risk aversion, a less risk-averse decision maker is able to increase the portfolio's expected net present value by increasing the ITFE (i.e., investment in the NFC payment technology). However, the portfolio risk also increases over-proportionally. This clearly illustrates the tradeoff between risk and return, a decision maker has to consider in the context of ITFE. Thus, there exists an efficient frontier which requires additional risk-taking for an additional return potential whereas the risk aversion determines how much risk a company is able or willing to take. Again, even if risk aversion regarding ITFE could be understood as aversion against ITFE (which have to be considered as very risky), ITFE even can reduce the IT innovation portfolio's risk and thus make sense even for risk-averse decision makers.

III.2.5 Conclusion

The decision process of whether and to which extent to engage with new emerging IT innovations (IT fashions, respectively) often enough does not follow a well-founded quantitative risk/return based analysis. Within this paper, we develop a model that applies portfolio and decision theory on the decision process of ITFE within an IT innovation portfolio. On the one hand, ITFE have to be considered as vastly risky and therefore do – from an isolated point of view – not seem to be from interest for an IT innovation portfolio. However, the application of portfolio and decision theory within this context shows that from a portfolio point of view, the addition of a risky asset like an ITFE can yield a significant gain for the whole IT innovation portfolio through diversification effects. A simple real world example that is based upon the model provides first results and recommendations for the IT innovation portfolio strategy concerning ITFEs. We show that the engagement in risky IT fashions can both, improve the risk position of an IT innovation portfolio and from a portfolio optimizing view, maximize the value of an IT innovation portfolio. Of course, our model also is limited due to several theoretical assumptions, simplifications, limitations and the challenge to estimate the values for the input parameters (e.g., cash flows, variance, correlation, risk aversion). Also, for reasons of simplicity and practical applicability we operationalize only the central characteristics of ITFE (higher risk from different sources and higher return potential, dependencies to non-ITFE) without incorporating aspects like long-term implications, development paths over time, or organizational learning through ITFE. However, the presented model can serve as a basis for further research within the field of ITFE in IT innovation literature and decrease gut feeling decisions. Future analytical research (e.g., based on real options theory) needs to answer the question, *when* to invest in IT fashion as this topic hitherto is only part of empirical and argumentative research. Within this context, also the long- and short-term effects of ITFE should be objective of further research as IT fashions usually are characterized by a significant latency concerning their value creation. To answer the mentioned and further research questions on the engagement in IT fashion, the presented paper serves as a first step within the analytical IT fashion research and therefore contributes to the understanding and improvement of this research stream.

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III.3 Research Paper 4: "The Error of Fixed Strategies in IT Innovation Investment Decisions"

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Abstract:

Allocating an IT Innovation budget to technologies in different maturity stages (mature vs. fashionable IT innovations) is a demanding task for companies. Due to the dynamic innovation cycles with new emerging technologies, many IT innovation investment decisions follow a bandwagon behavior or fixed investment strategies. Instead of optimizing the IT innovation budget's allocation to mature or fashionable IT innovations and following a mindful investment strategy, fixed strategies with naïve diversification are the rule in practice. To contribute to the decision making process regarding the IT innovation budget's allocation, we aim at the optimized allocation to mature and fashionable IT innovations via a dynamic optimization model incorporating the idiosyncrasies of IT innovations and a company's innovator profile. Though determining the optimum in practice seems to be virtually impossible, we argue that deviating above or below the theoretical optimum leads to a substantial difference regarding the IT innovation budget's value contribution. For that we examine the valuation error resulting from under- or overinvesting in mature and fashionable IT innovations due to

deviating from the theoretical optimum. By providing our ex ante dynamic optimization model and analysis we contribute to the decision making process regarding the engagement in new emerging IT innovations.

III.3.1 Introduction

The dynamic development of information technology (IT) regularly forces companies to decide whether, when and to which extent to adopt new emerging IT innovations or not (Swanson & Ramiller, 2004). Whereas IT innovations for many companies play a crucial role to create and sustain competitive advantage (Stratopoulos & Lim, 2010), rash investments in failing technologies like during the dot-com bubble which lead to a wave of bankrupts are the best warning not to engage with IT innovations which undergo a transient hype phase without thorough considerations (Fenn & Raskino, 2008). In contrast to *mature* IT innovations which already have been widely accepted and institutionalized, such IT innovations within a hyped phase due to their peculiarities are defined as *fashionable* IT innovations e.g. by Wang (2010), Baskerville and Myers (2009), as well as Fichman (2004b). Hence, IT fashion research examines a phase before a technology has to cross the chasm from being a fashionable IT innovation into a mature IT innovation (Wang, 2010) and bears both, the potential to develop into a disruptive as well as into a losing technology. Due to their novelty, fashionable IT innovations often heavily affect the IT infrastructure, business processes, or even the whole business model making investing in a losing technology a major threat (Fenn & Raskino, 2008). To learn about the chances and limitations of new technologies, companies "[…] need a steady stream of business and technology experiments" (Ross & Beath, 2002, p.55) and consider fashionable IT innovations not merely as a dayfly but as a persistent share of its innovation strategy (Stratopoulos & Lim, 2010). This raises our first research question:

RQ 1. What is a strategic IT innovation budget's optimal allocation to mature and fashionable IT innovations?

Though in theory there might exist an optimal allocation ratio regarding mature and fashionable IT innovations, management's uncertainty, missing data or political reasons often lead to fixed rules within IT innovation investment strategies (Nagji & Tuff, 2012; Swanson & Ramiller, 2004). Despite the fact that previous studies have found different fixed ratios to be suitable for different industries (Nagji & Tuff, 2012; Ross & Beath, 2002), such fixed strategies mostly deviate from the theoretical optimum and thus result in the error of under- or overinvestments. This raises our second research question.

RQ 2. How substantial is the potential error of under- vs. overinvesting in fashionable IT innovations resulting from common fixed strategies widely applied in practice?

As our literature review will show, research that considers fashionable IT innovations in a formal-deductive and mathematical model to the best of our knowledge is virtually absent. Williams et al. (2009) even demand for more variety regarding the methodology in IT adoption and diffusion research to avoid overall homogeneity. To contribute to the closure of this research gap, we apply a design-science driven research, a well-recognized methodology that aims on creating and applying specific artifacts to gain knowledge of a problem domain and so solves organizational problems (Hevner et al. 2004; Peffers et al., 2008; Wacker, 1998). This approach is furthermore closely related to the basic idea of the research cycle of Meredith et al. (1989) who emphasize that for research areas that are not thoroughly examined yet, qualitatively and mathematically approaches that predict first results provide the basis for generating hypothesis for future tests within empirical research. By that, we transfer central findings of IT innovation and IT fashion theory into a dynamic optimization model that enables determining the optimal IT innovation strategy considering mature and fashionable IT innovations. Knowing the optimal investment strategy then allows us to analyze the potential error of under- and overinvestments in mature or fashionable IT innovations that results from fixed investment strategies based on gut feeling decisions. The paper is organized as follows: First, we describe the idiosyncrasies of an engagement in fashionable IT innovations more in detail and give an overview on relevant literature. After that, we develop and analyze the model which aims on providing i) a new methodological approach in IT innovation research regarding fashionable IT innovations and ii) further assistance to practitioner's decisions. In the last section we discuss limitations and future research potential.

III.3.2 Problem Context and Related Work

In the next paragraph, we take a look at the lifecycle, an IT innovation experiences from being an experiment towards a broadly institutionalized technology and so depict the peculiarities in decision making regarding IT innovations within different stages of maturity. Subsequently, we review relevant literature regarding IT innovations and focus on literature which aims on the idiosyncrasies of fashionable IT innovations that require certain decision making approaches.

IT innovation lifecycle

Whereas traditional IT innovation research focuses on a lifecycle phase in which an IT innovation has already been widely accepted and taken for granted (=mature IT innovation), IT fashion research concentrates on IT innovations within their very early and middle phase of diffusion in which the "[…] legitimacy stems from fashion, regardless of what the destiny of the innovation eventually turns out to be." (Wang, 2010, p.82) (=fashionable IT innovation). The discourse around IT innovations and their adoption often is accompanied by fashion waves (Abrahamson & Fairchild, 1999) which follow a lifecycle that is closely linked to the concept of technology adoption cycles, originally sketched by Rogers (2003), and extended into "Hype Cycles" by the firm Gartner (Fenn & Raskino, 2008) from a practitioner's view. This concept illustrates an IT innovation's lifecycle starting with a *technology trigger* and excessive publicity leading to over-enthusiasm and investment decisions on the basis of bandwagon behavior. The hype usually ends up in a peak of *inflated expectations* before the hype fades away in a *trough of disillusionment*. These three milestones mark the phase in which an IT innovation has fashionable aspects and an unclear destiny. After this phase, opportunistic adopters often enough abandon ship, IT projects are scaled back and fashionable IT innovations might get stranded. Only few technologies are worth to continue experimenting with and to put solid hard work in understanding the technology's applicability, its risks and its benefits leading to a *slope of enlightenment* for the technology followed by a *plateau of productivity* (Fenn & Raskino, 2008). Hence, next to the technological risk that is associated with nearly every type of IT investment, investments in fashionable IT innovations additionally are associated with the risk of investing in a losing technology that never becomes institutionalized. In what follows, we show that common IT innovation literature tends to neglect these idiosyncrasies and why IT fashion research is a valuable contribution to (IT) innovation literature, especially regarding the lack of quantitative decision models.

Review of relevant literature

Traditional IT innovation literature mainly focuses on a set of variables like company size, structure, knowledge, or compatibility which form the company's innovator profile that affects the extent and ability of IT innovation adoption (Grover et al., 1997). Companies fitting this profile are expected to innovate easier, more effective and consequently more economic (Fichman, 2004b). However, several authors claim to consider other IT innovation related issues (e.g. probability of institutionalization) in the evaluation of IT innovation investments (Fichman, 2004a). Swanson and Ramiller (2004) or Fiol and O'Connor (2003) argue that companies should innovate mindfully by considering different types of IT innovations in their IT innovation strategy and apply a well-founded decision process. Such a decision process thereby e.g. should consider the expected destiny, i.e. that some IT innovations reach institutionalization whereas some are completely abandoned, adequately. In contrast, IT fashion theory extends the traditional focus on e.g., company size, structure, knowledge, and argues that the massive adoption of *certain* (IT) innovations not only is to explain through their simplicity or possible productivity increase but also through its propagation as the basis of dramatic potential improvements. Companies thereby tend to adopt IT innovations that are in fashion in the course of an action that is often negatively depicted as "bandwagon effect" (Abrahamson, 1991; Wang, 2010). For the justification of separate IT fashion research, Fichman (2004b) offers arguments that distinguish management fashions from IT fashions even though in practice, fashionable IT innovations often have administrative components and vice versa. They state that in contrast to management fashions, IT fashions often come along with high switching costs e.g. through the restructuring of IT infrastructure, tangible artifacts like software and hardware and are characterized by uniqueness due to various company individual implementation details which imply a different kind of decision-making processes (Wang, 2010). Lee and Collar (2003) found that IT fashions come more quickly than management fashions what requires separate attention. Literature in IT fashion research up to now is characterized by mostly qualitative or empirical papers which deal with the development, evolution, diffusion and impact of IT fashions on companies. In this context, Dos Santos and Pfeffers (1995) demonstrated that the very early engagement in new IT can add over proportional value. Hoppe (2000) in a game theory approach showed that under certain conditions, even second mover strategies can be advantageous due to spillover effects. Lu and Ramamurthy (2010) examined different strategies in stable and dynamic environments and showed general support for the assumption that proactive IT innovation leaders outperform reactive IT innovators in overall performance, allocation and cost efficiency. Wang (2010) found that companies that were investing in fashionable IT innovations have better reputation and improved performance due to over proportional returns resulting from competitive advantages in the long term. In the context of innovation persistence, Stratopoulos and Lim (2010) found that for becoming a systematic innovator, a steady engagement in new emerging IT innovations is required and that systematic innovators are more likely to outperform their competitors in the long-run. Though all this research provides valuable insights into the engagement in fashionable IT innovations' advantageousness and so contributes to decisions in this context, it stays on a rather generic level and does not provide decision models that consider the idiosyncrasies of fashionable IT innovations. However, the consideration of e.g., a fashionable IT innovation's risk of getting stranded plays a central role as those investments either can "[…] fail to produce expected benefits, or indeed, any benefits at all." or "[…] could produce some benefits, but not enough to recover the costs of implementation." (Fichman, 2004b, p.343). As one of the few, Kauffman and Li (2005) address this challenge and by applying a real options approach argue that technology adopters are better off by deferring investments until the technology's probability to become widely accepted reaches a critical threshold of ~60%. In contrast, most research even indicates a "more innovation is better" advice without differentiation in the allocation of a strategic IT innovation budget to different types of IT innovations. However, as determining this point of time equals a herculean task, the question of thoroughly analyzing whether, when and to which extent to invest in fashionable IT innovations remains unanswered. Hence, there is a rather high research need with respect to the ex ante analysis of investments in fashionable IT innovations as part of an

IT innovation strategy. Thus, our model's scope is the ex ante decision support for the allocation of a strategic IT innovation budget by firmly considering mature and fashionable IT innovations as investment alternatives. In a second step, we analyses the potential error that steams from applying fixed investment strategies as emphasized by e.g., Ross and Beath (2002) and Nagij and Tuff (2012) as such strategies might lead to under- or overinvestments in mature or fashionable IT innovations compared to the theoretical optimum. Our aim is to examine whether a strategy that under- or overinvests in mature and fashionable IT innovations is better off in case the theoretical optimum cannot be calculated exactly in practice.

III.3.3 Towards an Optimal IT innovation Investment Strategy

The model

In accordance with the design-science research guidelines by Hevner et al. (2004) we in the following develop our artifact, a dynamic optimization model for determining the optimal allocation of a strategic IT innovation budget to mature and fashionable IT innovations. According to Hevner et al. (2004), mathematical models are a common approach to represent an artifact in a structured and formalized way. For the evaluation, we in a second step combine an experimental and a descriptive design evaluation method which is a widely used approach for evaluating artifacts based on mathematical models (e.g. Wacker, 1998). For that, we describe a scenario in which a company decides on how to allocate an initial strategic (i.e. not periodic but mid-term oriented) IT innovation budget (ITIB) to two different types of IT innovations (mature IT innovations vs. fashionable IT innovations) in the next two periods to maximize its expected cash flows. The investment opportunities are clustered in these two major categories according to their discourse, diffusion, popularity and maturity (Tsui et al., 2009; Wang, 2009).

A) Mature IT innovations: IT innovations that, according to the concept of hype cycles already reached an evolution between slope of enlightenment and plateau of productivity (Fenn & Raskino, 2008) or according to Roger's (2003) theory already are adopted by a significant amount of the market but lack mass adoption. As their evolution can be roughly estimated, no early mover advantage can be realized any more as the competitive advantage is too low due to the reached maturity. Examples for mature IT innovations that in an earlier stage experienced a fashionable phase are Customer Relationship Management (CRM) or Enterprise Resource Planning (ERP) (Wang, 2010).

B) Fashionable IT innovations: IT innovations that, according to the concept of hype cycles are in an evolutionary phase between technology trigger and trough of disillusionment and thereby fashionable (Fenn & Raskino, 2008; Wang, 2010). Though their long-term evolution is unclear, they are accompanied by a hype through a fashion-setting network. An engagement promises first mover and therefore competitive advantages in case of wide adoption and institutionalization. However, the technology's immaturity makes estimations about a future evolution difficult as the hype might fade away without reaching a long-term productivity. Regarding today's situation of discourse in research and practice, we can state emerging IT innovations like 3D Printing or Near-Field-Communication (NFC) technologies as fashionable IT innovations (Gartner, 2012; Wang, 2010).

The part of the strategic IT innovation budget that is not allocated to mature or fashionable IT innovations in $t = 0$ is hold back as a strategic reserve to increase the investment budget later. It is used when the company intends to defer an investment until more information about an IT innovation's development is available. The resulting cash flows again are allocated in the same manner in $t = 1$ to generate cash flows in $t = 2$. Therefore, our model aims on determining the optimal allocation of the company's initial ITIB in $t = 0$ and the optimal allocation of the resulting cash flows in $t = 1$ to maximize the cash flows in $t = 2$ within a dynamic optimization model. Incorporating two periods in our analysis thereby allows us to model the most relevant time periods regarding the idiosyncrasies of fashionable IT innovations. Additionally, it keeps the mathematical model as simple as possible by simultaneously not limiting the central propositions for research and practice. In the following section we will outline the central assumptions of our model.

Assumptions and objective function

Assumption 1: In $t = 0$ we assume an initial strategic IT innovation budget $ITIB_0 > 0$ that is provided from the central IT budgeting planning to the IT innovation portfolio as strategic budget to work with for the planning horizon. Within the planning horizon, no extra budget will be provided so that $ITIB_1$ equals the cash flows that result in $t = 1$. We define $a_t^i \epsilon [0,1]$ with $i \epsilon \{N, F\}$ as the share of $ITIB_t$ that is invested in mature IT innovations (N) or fashionable IT innovations (F) in $t = 0,1$. Furthermore, we define $1 - a_t^N - a_t^F \geq 0$ as the share of $ITIB_t$ to be hold back in a strategic investment reserve R that allows deferring the investments until more information is available (Hoppe, 2000; Lu & Ramamurthy, 2010).

Figure III.5 shows the split of ITIB_0 into the two investment alternatives F, N, R and the cash flows that are realized in $\text{t} = 1$ (=ITIB_1) which then are allocated and generate cash flows in $\text{t} = 2$.

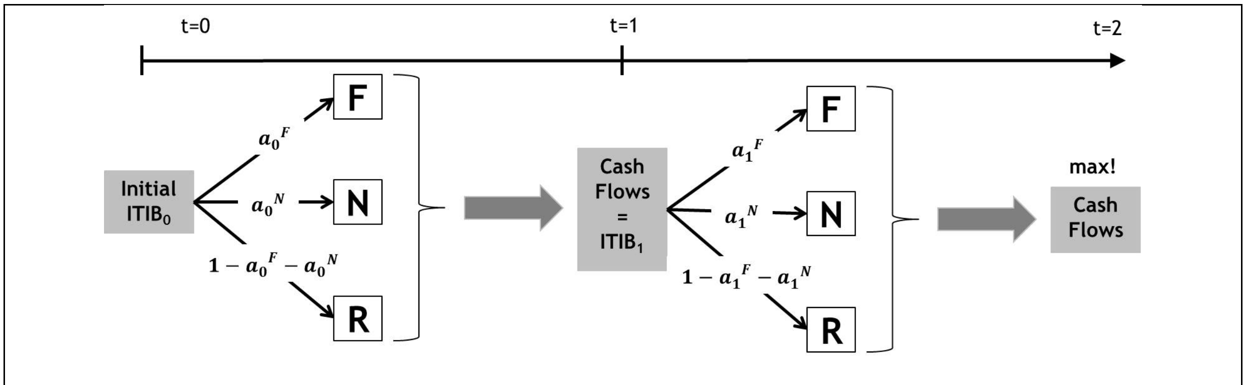

Figure III.5: The decision setting in t=0,1,2.

Assumption 2: The IT innovation portfolio's cash flow CF_t^{PF} for $t = 1,2$ consists of the investment's cash flows CF_t^F that result from the fashionable IT innovation investment, the cash flows CF_t^N that result from the mature IT innovation investment and the cash flows CF_t^R that result from liquidating the strategic reserve and its interest payments (e.g. resulting from investments in risk free assets).

$CF_t^{PF} = CF_t^F + CF_t^N + CF_t^R$ with $t \epsilon \{1,2\}$

To model the idiosyncrasies of the decision setting in more detail, we in the following take a closer look at the cash flows that are realized by N and F as well as R.

Assumption 3: The cash flows CF_t^F, CF_t^N, and CF_t^R in $t = 1,2$ depend on the IT innovation budget that was allocated to F, N, and R in the previous period. For simplification and easier interpretation, the cash flows in $t = 2$ are assumed to be a perpetuity and can be interpreted as the cash flows that are realized by the IT innovation budget from $t = 2$ on (Copeland et al., 2005). The cash flows CF_t^F and CF_t^N resulting from the investments in F and N follow a strictly monotonically increasing, concave function which is differentiable twice depending on a_{t-1}^i with $i \epsilon [N, F]$ and $t = 1{,}2$:

$$CF_t^i(\, a_{t-1}^i) = \left(a_{t-1}^i * ITIB_{t-1}\right)^{q_s^i} * v \text{ with } q_s^i \,\epsilon\, [0{,}1),\; i \,\epsilon\, \{N, F\}\,,\, t \,\epsilon\, \{1{,}2\}\,,\; s \,\epsilon\, \{u, d\}, v \,\epsilon\, R^+$$

The assumption of a strictly monotonically increasing function is reasonable due to the fact that in general, a higher investment and therefore commitment into an IT innovation allows for a deeper engagement and understanding of the technology, broader implementation and therefore, more opportunities to create value out of the investment (Fichman, 2004b; Kimberly, 1981; Melville et al. 2004) later on. However, a pure “more is better” approach must not hold true for every IT innovation investment: As companies need a minimum engagement to enter a market or become familiar with a technology reasonably, a first engagement in IT innovation usually creates more value than the additional increase of an already quite high investment spending. We thus can argue that an increasing investment into F or N is characterized by a diminishing marginal utility regarding $CF_t^i(a_{t-1}^i)$, i.e. $\partial^2(CF_t^i(a_{t-1}^i))/\partial^2 a_{t-1}^i < 0$, according to production theory (Varian, 1999). As an engagement in a failing fashionable IT innovation also can lead to zero cash flows, we in addition to the general cash flow form also model this important case.

The factor q_s^i with $i \,\epsilon\, \{N, F\}$ and $s \,\epsilon\, \{u, d\}$ that is constant over time can be interpreted as a technology specific impact factor that describes the impact degree of N and F, i.e. its general acceptance by customers or employees, stability, or the probability of an easy integration into the existing IT infrastructure of companies that influences the investment’s cash flow (Fichman, 2004a; Haner, 2002). As fashionable IT innovations, in case they get institutionalized and accepted by the market, usually have a higher impact and therefore generate higher cash flows for the company (Lu & Ramamurthy, 2010; Wang, 2010), we assume F’s technology factor q_s^F with $s \,\epsilon\, \{u, d\}$ generally to be higher than N’s q_s^N with $s \,\epsilon\, \{u, d\}$, i.e. $q_s^F > q_s^N \forall\, t = 1{,}2 \; with \; s \,\epsilon\, \{u, d\}$. However, as an IT innovation’s impact on the market is difficult to predict, we model an upside-scenario (with $s = u$), as well as a downside-scenario (with $s = d$) for N and F into the technology specific factor, i.e. $q_u^i > q_d^i \forall\ t = 1{,}2$ with $i \epsilon \{N, F\}$ and by that incorporate uncertainty about the IT innovation's possible outcome (Fenn & Raskino, 2008). Whereas upside scenarios regarding an IT innovation can be interpreted as e.g., high acceptance by customers or employees leading to higher cash flows or institutionalization in the first place (especially for fashionable IT innovations), a downside scenario can be characterized e.g., by difficulties within the integration in existing processes or even the case of getting stranded (in the case of fashionable IT innovations). Thereby, cases where the mature IT innovation in a positive scenario might have a higher impact than the fashionable IT innovation in a negative scenario, i.e. $q_d^F < q_u^N$, are possible. Though modeling only "positive" or "negative" scenarios is a rather binary view and simplifies real world scenarios that might lie somewhere in between, it incorporates the borderline cases which are of high relevance for this analysis.

The constant factor $v \epsilon R^+$ can be interpreted as the company's individual innovator profile indicator describing its ability to engage economically, quickly and efficiently with an IT innovation (Fichman, 2004b; Swanson & Ramiller, 2004). As companies that innovate steadily have more experience in integrating new IT in an existing infrastructure, to make employees adopt the new technology and based on an IT innovation create products that get accepted by customers, we assume those companies to have a higher innovation profile indicator (Stratopoulos & Lim, 2010). To enable an easier interpretation of the innovation profile v, we level a company that is on average or opportunistic innovative with $v^* \epsilon R^+$, non-innovators with $v < v^*$ and innovators, i.e. first and progressive movers with $v > v^*$ to transfer empirical findings by Stratopoulos and Lim (2010) as well as Lu and Ramamurthy (2010) into an analytical model.

Summarizing, both factors, the technology specific impact factor q_s^i with $i \epsilon \{N, F\}$ and $s \epsilon \{u, d\}$ as well as the company's individual innovator profile indicator $v \epsilon R^+$ consolidate a variety of different factors. Certainly, these factors again can be split up in several sub-dimensions that might be addressed in further research. However, as we focus on a more general level and to keep the balance between rigorousness and interpretability, simplifying from reality is reasonable in this case.

Assumption 4: Uncertainty about the mature and fashionable IT innovation's possible outcome (i.e. which of the scenarios q_u^i or q_d^i with $i \epsilon \{N, F\}$ occurs) and thereby the risk of undesirable outcomes is described by the probability p^i for upside-scenarios (with q_u^i) and $(1 - p^i)$ for downside-scenarios (with q_d^i) with $i \epsilon \{N, F\}$ via a binomial distribution. The probabilities p^i with $i \epsilon \{N, F\}$ are assumed to be constant over time as the uncertainty about future development within this very early phase of the adoption lifecycle can be assumed as almost equally high.

Hence, p^i with $i \epsilon \{N, F\}$ describes the possibility that an investment in N creates the desired cash flows (N^u with $\mathrm{q_u^N}$) in $t = 1{,}2$ or, in case of F, becomes institutionalized at all in $t = 1$ and creates desirable cash flows in $t = 2$ (F^u with $\mathrm{q_u^F}$). With $1 - p^i$ with $i \epsilon \{N, F\}$ we describe the probability that an investment in N creates below-average cash flows (N^d with $\mathrm{q_d^N}$) in $t = 1{,}2$ or, in case of F, becomes a losing technology in $t = 1$ or creates below-average cash flows in $t = 2$ after institutionalization in $t = 1$. In case F gets stranded in $t = 1$ (leading to zero cash flows), the company in this case only depends on the cash flows resulting from N in $t = 1{,}2$.

Assumption 5: The company is a risk neutral decision maker that aims on maximizing the net present value (NPV) of the IT innovation portfolio's expected cash flows $E(CF_t^{PF})$ with $t = 1{,}2$. The expected cash flows are discounted to present with a risk free interest rate $r > 0$ that is assumed to be constant for each period.

Assuming a risk neutral decision maker for a company's IT innovation portfolio's decisions is reasonable as an IT innovation portfolio per definition deals with more risky investments than e.g. an IT asset portfolio that deals with infrastructure, operational data and routine processes (Maizlish & Handler, 2005; Ross & Beath, 2002). Hence, an approach with a risk-averse decision maker would possibly lead to inadequate conservative investment decisions limiting the company's innovativeness.

Cash Flows in t: The IT innovation portfolio PF in t realizes cash flows from the investments in F, N, and R, respectively. According to our assumptions, investing in a fashionable IT innovation F or a mature IT innovation N in $t-1$ can result in the following cash flows $\mathrm{CF}_{\mathrm{t}}^{\mathrm{F}}$ or $\mathrm{CF}_{\mathrm{t}}^{\mathrm{N}}$ with $t=1{,}2$:

Table III.5: Scenarios for the IT innovation's cash flow			
		$t=1$	$t=2$
Upside scenario (p^i) with $i \epsilon \{N,F\}$	F	$(a_0^F * ITIB_0)^{q_u^F} * v$	$(a_1^F * ITIB_1)^{q_u^F} * v$
	N	$(a_0^N * ITIB_0)^{q_u^N} * v$	$(a_1^N * ITIB_1)^{q_u^N} * v$
Downside scenario $(1-p^i$) with $i \epsilon \{N,F\}$	F	0	$(a_1^F * ITIB_1)^{q_d^F} * v$
	N	$(a_0^N * ITIB_0)^{q_d^N} * v$	$(a_1^N * ITIB_1)^{q_d^N} * v$

As predictions on the future impact of certain technologies are easier in later periods, the company in $t=0{,}1$ may hold back a strategic reserve to be able to defer IT innovations investments. The cash flow $\mathrm{CF}_{\mathrm{t}}^{\mathrm{R}}$ that results from liquidating this strategic reserve and its interest payments that was hold back in $t-1$ has the following form for $t=1{,}2$:

$$CF_t^R(a_{t-1}^N, a_{t-1}^F) = (1 - a_{t-1}^N - a_{t-1}^F) * ITIB_{t-1} * (1+r)$$

The cash flow $CF_1^{PF} = CF_1^F + CF_1^N + CF_1^R$ that results from the allocation of the initial strategic IT innovation budget in $t=0$ ($ITIB_0$) forms the basis for further investments (=$ITIB_1$) in $t=1$:

$$ITIB_1 = CF_1^F(a_0^F) + CF_1^N(a_0^N) + CF_1^R(a_0^F, a_0^N)$$

After describing the particular decision making problem and possible scenarios and cash flow outcomes for $t=1{,}2$, we can now state the objective function of our model. According to the outlined decision problem, the company aims to maximize the net present value (NPV) of the IT innovation portfolio's expected cash flows $\mathrm{E}(\mathrm{CF}_{\mathrm{t}}^{\mathrm{PF}})$ with $\mathrm{t}=1{,}2$ by allocating $ITIB_0$ and $ITIB_1$to F, N, and R. Hence, the objective function is from the following form:

$$\max_{a_0^F, a_0^N, a_1^F, a_1^N} -ITIB_0 + \frac{E(CF_2^{PF})}{r*(1+r)} \quad s.t.$$

$$0 \le a_t^i \le 1 \qquad \forall t=0{,}1;\ \forall\, i \in \{N,F\}$$

$$0 \le a_t^F + a_t^N \le 1 \qquad \forall t = 0{,}1$$

$$ITIB_t = CF_t^{PF}(a_{t-1}^F, a_{t-1}^N) \text{ with } t=1$$

Model evaluation

We approach this dynamic optimization problem by analyzing different scenarios regarding the evolution of F an N and conduct a Bellman-roll-back analysis (Clemons & Weber, 1990; Magee, 1964). By that, we start at the last decision point and first determine the optimal allocation for $ITIB_1$ in $\mathrm{t} = 1$ by taking possible cash flows in $\mathrm{t} = 2$ into consideration. The company in this situation assumes different scenarios to be realized in $\mathrm{t} = 1$ and under this condition, optimizes the allocation of $ITIB_1$ leading to $a_1^{F^*}$, $a_1^{N^*}$ and, $1 - a_1^{F^*} - a_1^{N^*}$, respectively. In a second step, the company, knowing the optimal allocation for $\mathrm{t} = 1$ then determines the optimal allocation for $ITIB_0$ in $\mathrm{t} = 0$ by taking possible cash flows in $\mathrm{t} = 1$ into consideration, leading to $a_0^{F^*}$, $a_0^{N^*}$ and, $1 - a_0^{F^*} - a_0^{N^*}$, respectively. After that, the company repeats the optimization and possibly re-allocates its IT innovation strategy according to the realized scenarios or when new information is available. A real option approach as applied by Kauffman and Li (2005) or Fichman (2004a) might also have been suitable to address this decision setting but inherits restrictive assumptions as e.g., the existence of a twin security, and so is not suitable for an ex ante allocation of an IT Innovation budget. Though the objective function allows for solving it analytically, the number of input parameters (e.g., q_d^F, v) limits the interpretability of an analytical solution. Though acquiring real world data to examine the benefits of our theoretic approach profoundly is rather difficult, considerable advantages can be realized by incorporating the results from the model in decisions regarding the allocation of a strategic IT innovation budget. According to Hevner et al. (2004), the analytical evaluation or gathering data by simulation are legitimate means for evaluating artifacts based on mathematical models. Thus, to derive first results, we conducted a Monte Carlo simulation, for which we generated 1,000 different investment settings in which we randomly changed *all* parameters of major influence. We chose 1,000 investment settings as the results changed only slightly with an increasing number of investment settings but on the other hand increased the simulation runtime rapidly. Table III.6 shows the initial values and their ranges which are relevant for the simulation. For our analysis, the values in the table serve as starting points. For the sake of simplicity we in the following speak of v, q_s^i and p^i with $i \in \{F, N\}$ and $s \in \{u, d\}$ and assumed equal distributions as other distributions like Gaussian would not distort the general results but increase complexity. For the risk free interest rate r, we took a value $r = 0.1$ in analogy to Kauffman and Li (2005). The optimization was conducted on the basis of a self-developed MS Excel tool while using the Frontline GRG-Nonlinear (Generalized Reduced Gradient) solver as optimization algorithm which aims at continuous nonlinear problems. We started our analysis and optimization with rather conservative values and let the relevant parameters range in conservative intervals to avoid distortion due to overoptimistic value estimations. Due to space restrictions, we in the following focus on the ex ante analysis in $t = 0$. Additionally, we analyze the potential error that occurs from deviating from the theoretical optimum by applying a fixed investment strategy. Thus, we are able to examine whether under- or overinvestments in IT innovations are beneficial.

Table III.6: Data for Sensitivity Analysis and Monte Carlo Simulation

Parameter	Initial Value	Range
Company's individual innovator profile indicator v	100 ($= \mathrm{v}^*$)	70 – 130
Fashionable IT innovations impact factor q_u^F (upside scenario)	0.5	0.2 – 0.5
Fashionable IT innovations impact factor q_d^F (downside scenario)	0.3	0.05 – 0.3
Mature IT innovations impact factor q_u^N (upside scenario)	0.35	0.1 – 0.35
Mature IT innovations impact factor q_d^N (downside scenario)	0.2	0.01 – 0.2
Probability that fashionable IT innovation creates desirable cash flows p^F	0.05	0.01 – 0.2
Probability that mature IT innovation creates desirable cash flows p^N	0.4	0.2 – 0.4

Simulation of all parameters

Simulating all parameters leads to a broad range of values for $a_0^{F^*}$ between 0.24% and 87.08%. This is due to the high number of possible constellations regarding the parameters. Analyzing an extremely unrealistic case with e.g. a low value for p^F (4.45%), an average value for p^N(28.27%) which always is above 20% and simultaneously the unrealistic case of $q_u^F < q_u^N$ (which by our assumptions is even excluded) as well as the case of a below-average innovative company ($v = 71$) shows interesting and counter intuitive results. Even in this case, the company is better off by investing a very slight amount (1.25%) in fashionable IT innovations (see Figure III.6). In this analysis, companies on average should invest a reasonable amount of about 16.36% in fashionable IT innovations.

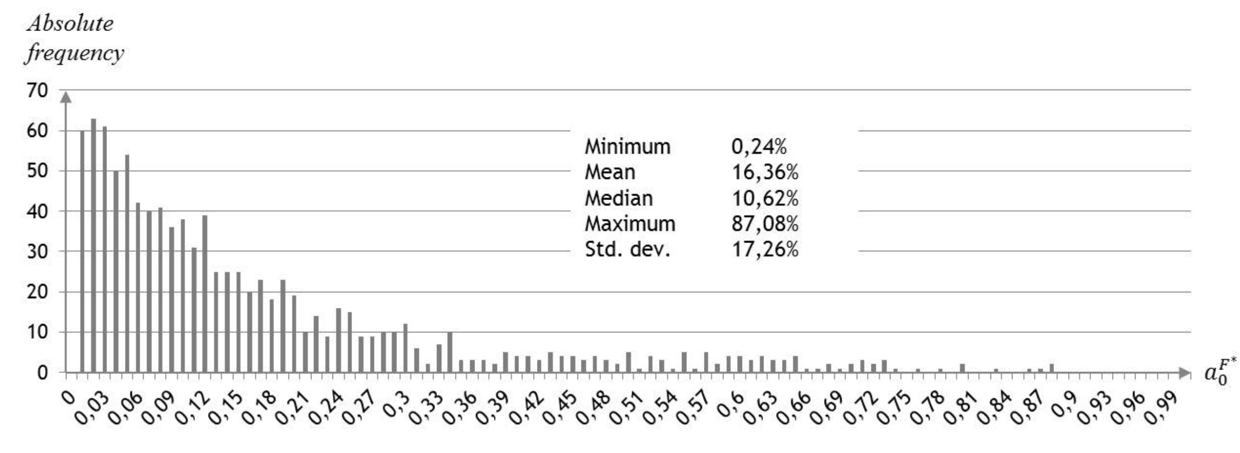

Figure III.6: Results for $a_0^{F^*}$ after Monte Carlo Simulation regarding $q_u^F, q_d^F, q_u^N, q_d^N, p^F, p^N, v$.

The error of fixed IT innovation investment strategies on a gut feeling

Though our results theoretically show the existence of an optimal ex ante IT innovation portfolio investment strategy, individual company profiles, high estimation uncertainty regarding model parameters or political reasons might impede a direct transfer to real world business decisions. This in practice often leads to fixed rules for IT innovation investment strategies. Previous literature empirically (Nagji & Tuff, 2012; Ross & Beath, 2002) provided such fixed investment rules for different kinds of (IT) innovations for different industries. However, such fixed strategies that are comparable to naive rules of diversification in financial portfolio theory by nature differ from the company's individual optimal investment strategy. Taking our model, for each simulation run i with $i \in \{1, \dots, 1000\}$ we can determine the valuation error Δ_i^{err} by comparing the IT innovation portfolio's optimal NPV_i^{opt} with the $\mathrm{NPV}_{i,j}^{fix}$ that results from applying a certain fixed investment strategy j (i.e., j represents one fixed combination of investment shares a_t^F and a_t^N):

$$\Delta_{i,j}^{err} = \frac{\mathrm{NPV}_i^{opt} - \mathrm{NPV}_{i,j}^{fix}}{\mathrm{NPV}_i^{opt}}$$

To demonstrate the calculus, we regard different scenarios with fixed investment strategies regarding mature and fashionable IT innovation investments. To examine the valuation error, we keep one share constant (with $a_t^N = 0.2$ and $a_t^F = 0.1$, respectively with $t = 0{,}1$) and slightly change the other one (with $a_t^F \in [0; 0.2]$ and $a_t^N \in [0; 0.4]$ with $t = 0{,}1$, respectively) and so obtain different fixed strategies j. For every fixed strategy j, we calculate the *average valuation error* $\Delta_{avg,j}^{err}$:

$$\Delta_{avg,j}^{err} = \frac{1}{1000} \cdot \sum_{i=1}^{1000} \Delta_{i,j}^{err}$$

In the following, we illustrate the $\Delta_{avg,j}^{err}$ depending on the share that is allocated to fashionable IT Innovations (Figure III.7) and mature IT innovations, respectively (Figure III.8).

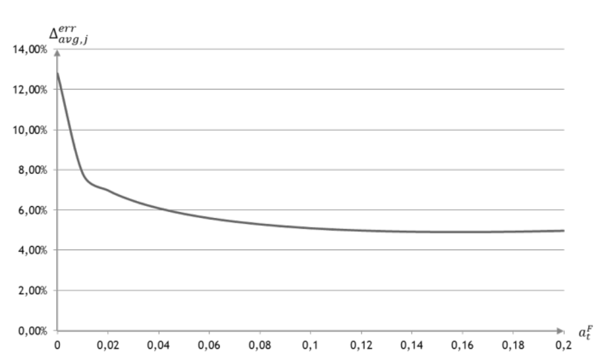

***Figure III.7:** $\Delta_{avg,j}^{err}$ **depending on** a_t^F*

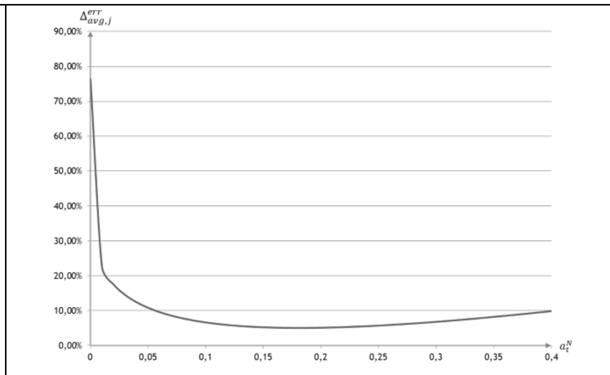

***Figure III.8:** $\Delta_{avg,j}^{err}$ **depending on** a_t^N*

Figure III.7 and Figure III.8 illustrate that the average valuation error of fixed investment strategies ranges between 4.90% and 12.80% when deviating from the optimum regarding fashionable IT innovations (with an average $a_t^{F*} = 16.36\%$) and ranges between 5.04% and 76.45% when deviating from the optimum regarding mature IT innovations (with an average $a_t^{N*} = 18\%$). Hence, the potential damage is substantially higher when deviating from the optimum in mature IT innovations than in fashionable IT innovations. This is reasonable as an IT innovation portfolio requires basic and evolutionary IT innovations to ensure competitive advantage (Maizlish & Handler, 2005; Ross & Beath, 2002). Neglecting these important basic IT innovations and e.g. "gambling" with fashionable IT innovations or holding back too much in a strategic reserve destroys value. Furthermore, our results generally reveal that underinvesting (with respect to the theoretical optimum) generally leads to a profoundly higher marginal increase of the average valuation error than overinvesting.

Discussion of the results

Though different model settings, simplifying assumptions or model-specific parameters limit comparison between different research approaches, it is worth to discuss our results with regard to existing research: By applying our ex ante mathematical model and optimizing a strategic IT innovation budget allocation, we find an average optimal allocation to fashionable IT innovations of 16.36%. Thus, according to our model it is beneficial to invest a significant amount of the strategic IT innovation budget to technologies with a rather uncertain future development. We also find overinvestments in fashionable IT innovations as favorable compared to underinvestments and underinvestments in mature IT innovations to be a substantial threat. The results of our ex ante model basically are in line with previous qualitative and empirical findings like Nagji and Tuff (2012) who find that the most innovative companies in the technological sector on average invest about 15% of their innovation portfolio spending in innovations that aim on breakthrough technologies. We also support the empirical findings of Ross and Beath (2002) who analyzed allocation of IT budgets to IT experiments in different industries and found ranges from 3% to 15% - values. The advantageousness of an early adopter strategy with a significant engagement in fashionable IT innovations is comparable with the results of empirical research of Wang (2010), Lu and Ramamurthy (2010) or Dos Santos and Pfeffers (1995) who show that the engagement in fashionable IT innovations and being a proactive IT leader leads to higher performance. The result of being better off by over-investing in fashionable IT innovations goes in line with Stratopoulos and Lim (2010) who emphasize the importance of persistent consideration of emerging IT innovations. We deviate from the findings of Kauffman and Li (2005) who suggest adopting a new technology only when its probability to win is greater than 60% as we propose an investment strategy that by tendency leads to overinvestments in fashionable IT innovations to be beneficial even in case when the probability is considerably lower. In the following, we discuss practical implications, limitations of our approach as well as aspects worth to examine in future research.

III.3.4 Theoretical and Practical Implications and Limitations

IT innovation investment decisions often enough follow a gut feeling rather than a well-founded analysis. We approach this challenge by a dynamic optimization model that optimizes the allocation of a strategic IT innovation budget to *mature and fashionable IT innovations.* We theoretically show the existence of an optimal investment strategy in fashionable and mature IT innovations which complies with the constraints of our decision framework. Our approach covers specifics of IT innovations like their uncertainty and their technology specific impact factor as well as company characteristics like the company's individual innovator profile. As determining such an optimal investment strategy in practice is limited due to missing parameter estimations, companies often apply fixed allocations to different IT innovations types. We address this challenge and analyze the average estimation error of different fixed IT innovation portfolio strategies that occurs by deviating from the optimal strategy. This allows for deriving the following implications for research and practice:

When randomly simulating all major influencing parameters, companies on average should invest a reasonable amount of their IT innovation budget in fashionable IT innovations even though their success probability has not reached a high threshold [*whether?*]

When applying a fixed strategy, a company is better off by an overinvestment strategy regarding fashionable IT innovations than by an underinvesting strategy [*when?*]

An IT innovation portfolio investment strategy that underinvests in mature IT innovations and instead e.g. "gambles" with fashionable IT innovations or holds back too much in a strategic reserve in the long-term destroys value [*to which extent?*]

Though we aim on a methodically rigor model that delivers initially reasonable results, it might not be applicable in practice without some adjustments. Following Kauffman and Li (2005, p.25), we aim at "[…] an analogy between the technical details of the decision model and the exigencies of its application in an appropriate managerial context". Despite the fact that our model pictures reality in a slightly constrained way, the results are comparable with previous qualitative and empirical literature and thus complements it by providing a basis for the ex ante decision support and improvement of an IT innovation investment strategy. The specific design of our ex ante decision situation, other guidelines and assumptions also might explain differences in results which partially deviate from previous research. Some aspects that are not covered or that need further methodological effort are the incorporation of switching costs, spill-over effects, risk, and n-period analysis or learning aspects. Furthermore, an empirical testing of the model and its parameters as different dimensions of q or v with real world data is due to further research. Also, opposing our approach with different model settings of previous work and so analyzing differences or similarities of the results is not covered yet. It is also to mention that the model's inherent interpretation of the IT innovation's value is rather abstract, i.e. it is limited to deal with quantifiable and attributable value components. We also do not consider that a technology might require a minimum engagement. To sum it up, our model can serve as a basis for developing hypothesis which might be tested in further empirical research to close the research cycle between design-science and behavioral-science (Hevner et al., 2004; Wacker, 1998).

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IV Evaluating the engagement in Open Innovation for developing (fashionable) IT innovations (Research Paper 5: "A Quantitative Model for Using Open Innovation in Mobile Service Development")

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Please note that this is a slightly advanced version of the paper in the conference proceedings |

Abstract:

The potential of mobile service innovations to create valuable economic impact makes their development desirable for companies. To develop and launch successful mobile services, the integration of customers in the idea generation process bears high potential. However, such Open Innovation activities usually demand for investments, whereas the precise relation between the money invested and the generated economic effect is still indistinct. The objective of this paper is to replace the black box between investments in Open Innovation and the thereby generated profits through formal-deductive analysis. For this purpose, we analyze the effect chain between Open Innovation and economic profit by adapting the model of Kano and putting special *emphasis on the specifics of mobile services. Building on that, we develop a quantitative formal model to determine the optimal investment amount in Open Innovation activities for mobile services. The model's utility is illustrated with an example based on real world data.*

IV.1 Introduction

According to recent studies, the market for mobile services via mobile apps will grow to €115 billion globally and €32 billion in the European Union by 2020 (PAC, 2010). The study's results point out that mobile service innovations can generate valuable economic impact for companies. Simultaneously, competition is expected to grow dramatically leaving some industries behind if they are not able to offer innovative mobile services that create customer satisfaction and consequently profits. For developing and launching successful mobile services, customer integration in the idea generation process bears high potential, as one prior risk of new service development results from the narrow range between inventing a sought-after service on the one hand and creating something that does not meet the market needs at all on the other hand (Luethje et al., 2005). Regarding the mass of mobile services, the speed of technological advancements, and an average failure rate of 35-60 % of new products in the consumer markets, companies need a quick development of mobile services that meet the customers' expectations (Atuahene-Gima, 1995; Luethje, 2007). One possibility for customer integration is Open Innovation (OI), a management paradigm according to which companies use the purposive inflow of knowledge to accelerate innovation (Chesbrough, 2003). Various companies from different industries apply OI activities to integrate customers in the development of mobile services as shown by HTC's "Tomorrow Talks", Google's "2012 Apps Developer Challenge" or Hilti's "2013 Mobile App Competition". However, though some companies have developed methods for the economic analysis of activities and decisions regarding innovation and technological collaboration (Dogson et al., 2006), only in very few cases, "[…] financial analyses are used to support decision-making concerning innovations and technological collaboration" (Lazzarotti & Manzini, 2009, p.631). Hence, the precise relation between OI activities and economic profit is indistinct and well-founded economic decisions regarding OI are missing. We approach this research gap by developing a formal-mathematical model that is based on the relations between OI, customer expectations and customer satisfaction of mobile services. The focus on mobile services is useful since mobile services are characterized by e.g., high customer product knowledge and quick and easy development and update possibilities with continual feedback opportunities for the users making them a very appealing object for OI activities. We derive important aspects of the well-recognized work of Kano et al. (Kano et al., 1984) who laid a strong foundation for research on customer satisfaction. The objective of this paper is to replace the black box between investments in OI activities and the generated economic profit by analyzing the effect chain between the two. Consequently, we formalize the whole effect chain putting special emphasis on the specifics of mobile services. We aim at determining the optimal investment amount in OI activities for mobile service development and illustrate our findings with an example on the basis of real world data from an industry project.

IV.2 Relevant Literature

Integrating customers in the creation and design of new services is part of research discourses since the early 1980s. Von Hippel (1986) quite early presented the lead user concept as users can provide more accurate data on future needs. Other authors emphasize the customers' contribution to the concept, design, performance testing or validation in the development of new products and services (Gruner & Homburg, 2000; Kleinschmidt & Cooper, 1991; Lengnick-Hall, 1996). The effectiveness and benefits in form of more customer-oriented products that meet expectations more precisely is stressed by various past and recent research papers and studies (Atuahene-Gima, 1995; Bogers et al., 2010; Fuchs & Schreier, 2011). Next to the benefits, also risks associated with customer integration in innovation processes are examined (Enkel et al., 2005). Turning away from internal and isolated idea creation in the beginning was called "Open Innovation" by Chesbrough (2003). "New information and communication technologies (ICT) have reduced the perceived distances between the actors of the innovation process […]" (Gassmann, 2006, p.223) and so allowed for a broader integration of customers. OI experienced a vital exchange in research as well as in practice in the last decade and is expected to increase further over the next few years (Gassmann et al., 2010; Howells, 2008). Though literature is rich of qualitative case-study research and OI best practices in different industries, different kinds of users or different stages of the innovation process, research aiming at the economic valuation of investments in OI activities is virtually non-existent. The analysis of van de Vrande et al. (2010) who examined a broad range of OI publications within the last decade show a lack of formal-methodological approaches that aim at an economic valuation. The rising impact of mobile devices and the dramatically increasing market for mobile services and products requires innovative services that serve the customer's mobility needs. Bouwman et al. (2008) for that stress the importance and relevance of OI approaches for mobile service models as companies in this area often lack experience and best practices. Hence, integrating customers in the innovation process within an OI approach seems to be promising for mobile service development (Bouwman et al., 2008; Reichwald et al., 2002). However, experience from past open or traditional innovation approaches have to be adapted with regard to mobile services as the speed of technological advances regarding mobile devices and hence the possibilities of mobile services do not fit in regular innovation processes. Yet, literature still lacks contributions that provide methods for determining the right amount on how much to invest in mobile service OI activities and how the effect chain between OI and customer satisfaction works. As one of the few papers, Platzer (2011) extended the classic Technology Acceptance Model and developed a taxonomy that enables user integration in terms of an OI approach for automated classification of user reviews. This enables a learning environment within mobile app development during the innovation process to increase the probability to develop mobile apps that meet the customers' needs. In the very early stage of mobile services, Aalto et al. (2004) described the prototypical implementation of an OI approach for the development and testing of mobile applications. Based on our literature review and the finding that "[…] future research has to continue to broaden the scope of open innovation research to exploit its full potential" (van de Vrande et al., 2010, p.230), we find a research gap regarding OI approaches in the innovation process of mobile services in general. Additionally, research lacks well-founded economic analysis and formal-methodological models that aim at the determination of the optimal investment amount in OI activities for mobile services in particular.

IV.3 Open Innovation and the Kano Model for Customer Satisfaction

In order to increase revenue generated through mobile services, companies increasingly open up their innovation process. However, as stated above, the precise relation between OI investments and thereby generated revenue is still indistinct leading to a lack of well-founded economic decisions regarding investments in OI activities.

Figure IV.1: Black box between investments in OI activities and thereby generated revenue.

As we will show in the following, simply assuming that higher investments in OI activities will always increase the revenues of mobile services neglects important aspects of OI. In the following, we firstly analyze the direct effect of OI activities on the over-fulfillment of customer expectations. Consequently, we analyze the relation between the over-fulfillment of customer expectations and customer satisfaction using the Kano model. On that basis, we can analyze the idiosyncratic relationship between investments in OI activities for innovative mobile services and customer satisfaction. After that, we develop a formal model to determine the precise relation between investments in OI activities and revenue under consideration of all mentioned elements of the effect chain. Figure IV.2 illustrates our analysis process and points out the major contribution of our approach.

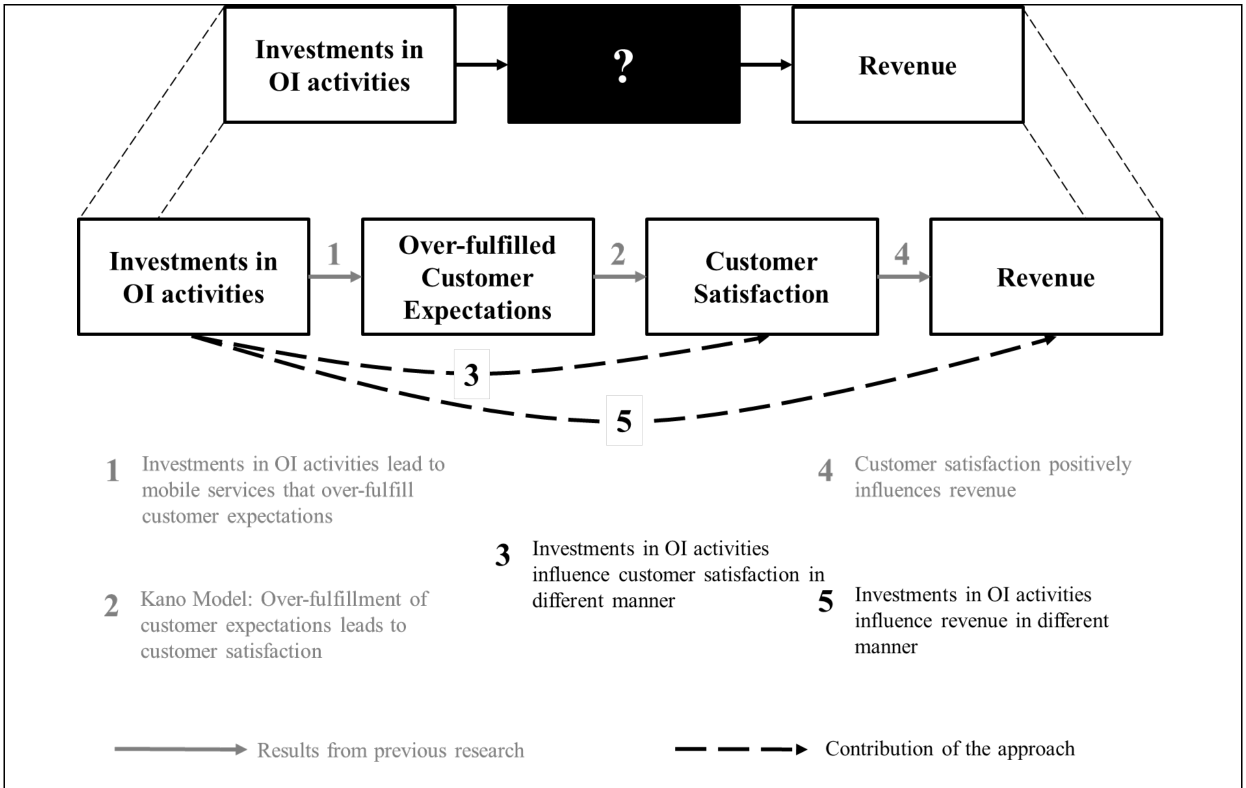

Figure IV.2: Effect chain between OI investments and revenues.

Open Innovation activities and over-fulfillment of customer expectations

Initially, literature states that the integration of customers in the innovation process reduces the risk of developing mobile services which do not meet customer needs (Reichwald et al., 2002). This is due to the fact that integrating the customer allows for a much deeper level of individualization especially regarding mobile services (Reichwald et al., 2002) since mobile services by nature require individualization and are very familiar to today's customers. For that, companies need to integrate customers early, significantly and along the whole innovation process regarding new products like mobile services (Matthing et al., 2004; Reichwald et al., 2002). Consequently, we are in line with Enkel et al. (2005), Bruce and Biemans (1995), and Kohli and Jaworski (1990) when we conclude that investments in OI activities positively influence the possibility to create auspicious mobile services that lead to over-fulfillment of customer expectations.

Over-fulfillment of customer expectations and customer satisfaction

Meeting or even over-fulfilling customer expectations is not a direct driver of quantifiable financial results. For that, we have to take a closer look on customer satisfaction which directly leads to financial impacts for the company (Buhl et al., 2007; Gneiser, 2010; Ittner & Larcker, 1998, Mittal et al., 2005). In order to determine customer satisfaction (Oliver, 2009), the confirmation/disconfirmation paradigm is a widely spread and well acknowledged method. In case a considered service over-fulfills customer expectations, it is above a customer's so called confirmation level and thus generates customer satisfaction and vice versa. The Kano model (Kano et al., 1984) distinguishes three different kinds of attributes of a product or service, which determine customer satisfaction through the respective over-fulfillment of customer expectations.

Must-be attributes are considered fundamental and natural by the customer. Under-fulfillment of must-be attributes leads to customer dissatisfaction. However, over-fulfilled expectations of must-be attributes will not increase customer satisfaction as must-be attributes are perceived only implicitly. Must-be attributes of mobile services e.g. are implicit expectations regarding availability and stability.

One-dimensional attributes generate dissatisfaction or satisfaction depending on the extent of a service's over- or under-fulfillment of expectations. Over- /under-fulfilling expectations towards a one-dimensional attribute leads to a proportional increase / decrease of customer satisfaction. Customers are aware of one-dimensional attributes and explicitly demand them. Application speed or productivity increases are examples for a mobile service's one-dimensional attributes.

Attractive attributes are service features that are not expected by customers. Over-fulfillment of customer expectations by developing services that include attractive attributes leads to a disproportional increase of customer satisfaction. With regard to mobile services, attractive attributes e.g. are unique and breakthrough solutions to problems, customers were not even aware of in advance (Buhl et al., 2007). Figure IV.3 illustrates the determinants of customer satisfaction following Kano et al. (1984).

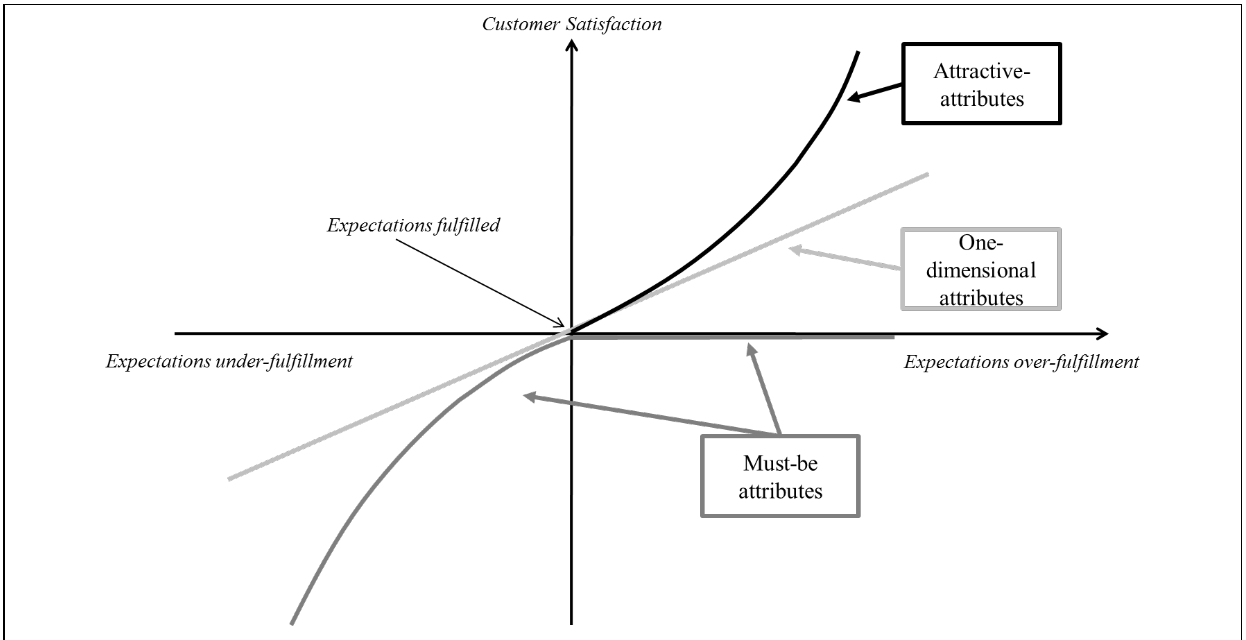

Figure IV.3: Effect chain between OI investments and revenues.

The influence of must-be attributes on customer satisfaction is illustrated as a monotonically increasing, concave function in the section of expectations under-fulfillment. Above the confirmation level, must-be attributes do not contribute to customer satisfaction, resulting in a linear, non-increasing or decreasing function. The influence of one-dimensional attributes to customer satisfaction is consequently directly proportional. Finally, the high contribution of attractive attributes is illustrated as a monotonically increasing, convex function in the section of expectation over-fulfillment. As customers do not expect attractive attributes, they are not defined for the case of under-fulfillment.

We in the following will discuss idiosyncrasies of OI activities on customer satisfaction when applied in mobile service development.

OI investments and the attributes of customer satisfaction of the Kano model

According to Peppers and Rogers (2001) exploiting the customer's knowledge through integration in the innovation process can be a key success driver for increasing customer satisfaction. As such OI activities aim at the generation of innovative and completely new mobile services, we argue that OI activities in the first place produce attractive attributes of services and do not produce must-be or one-dimensional attributes. Regarding must-be attributes, this is due to the fact that customers perceive must-be attributes only implicitly whereas mobile service innovations can assumed to be perceived explicitly. One-dimensional attributes make existing functions quicker, cheaper or at higher quality and are explicitly demanded by customers, i.e. they are neither generated by OI activities in the first place. Consequently, OI activities in the first place only produce attractive attributes which, in case of over-fulfillment, are surprising for the customer and hence lead to customer satisfaction. Increased customer satisfaction through attractive attributes then directly links OI activities to customer loyalty, long-term competitive advantage and thus financial impact (Heidemann et al., 2011; Matzler & Hinterhuber, 1998). However, OI activities produce customer satisfaction through attractive attributes only in the first place and not constantly. In case of mobile service development, conducting several OI activities is not likely to reveal always more innovations, but can create one-dimensional or even only must-be attributes.

The subsiding impact of mobile service OI activities on customer satisfaction

As illustrated in the previous section, investments in OI activities positively influence customer satisfaction by leading to services with attractive-attributes that over-fulfill customer expectations. Consequently, one could assume that the execution of all OI activities available always makes good economic sense. Yet, mobile services show some idiosyncrasies that speak against this assumption and that are to consider when applying OI activities. Though technological developments as web-based social collaboration methods today allow for customer integration at reasonable costs for infrastructure – transaction costs, consultancy, legal expenses, software tools etc. still state for significant investment payouts linked with OI activities in the early and middle phases of mobile service development (Homburg & Stock, 2001; Reichwald et al., 2002). Furthermore, the positive contribution of OI to customer satisfaction usually slows down throughout its use (Buhl et al., 2007): Product features identified through OI activities that initially created unexpected excitement later on are considered as normal by the customer (Homburg & Stock, 2001). These product features increasingly lose their positive influence on customer satisfaction and, as a consequence, their status as a service’s attractive attribute. In this vein, a mobile service’s attractive attributes can become one-dimensional attributes and one-dimensional attributes can become must-be attributes (Buhl et al., 2007) as implied above. The extent of this negative effect depends on the amount of customers, which experience true excitement by surprising mobile service features on the one hand and the amount of customers, which already have expected the mobile service innovation on the other hand. Regarding OI activities, all customers involved in the service development process are likely to belong to the second group. Customers that took part in the idea generation process are likely to know and expect innovative product features already before the mobile service is on the market. If features that were discussed in the innovation process or submitted by the customers are not implemented or only to a limited extent, this is likely to lead to disappointment of customers who took part in the OI activity. The positive influence of OI activities on customer satisfaction will then be solely determined by the degree to which the explicitly raised expectations will be fulfilled (through one-dimensional or basic attributes). All other customers will be delighted by the innovations through excitement attributes. Beyond that, it is also conceivable that over a certain threshold, OI activities do not generate additional customer satisfaction at all or even negatively influence customer satisfaction. Customers contacted repeatedly and on versatile marketing channels by companies executing large scale OI activities can react with rejection which causes decreasing customer satisfaction (Enkel et al., 2005; Leonard, 2002). The former positive influence of creating a fashion around an OI activity can then turn the OI activities into a transient fad which only attracts bandwagon behavior instead of thorough collaboration with breakthrough ideas for new mobile services. This subsiding effect of OI is especially important for our consideration, since mobile service customers are significantly more online and usually well connected to each other via their mobile device (e.g. by social networks). The consequently tend to spread negative experiences with innovative services and rejection with high frequency, extremely fast and with a potentially huge dispersive character.

IV.4 The Model

In the following, we introduce a formal-deductive mathematical model that aims at optimizing the investment amount in OI activities regarding the trade-off between the up- and downsides of OI activities in mobile service development mentioned above.

Though determining the optimal amount of OI activities seems suitable to a broad range of products beyond mobile services, it seems particularly useful for mobile service development due to the following idiosyncrasies: *First*, mobile services by nature are services where customers are eager to engage in since their utility directly is perceived by the customer. *Second*, due to the vast number and variety of mobile services, the ease of installation and low costs, customers have a broad knowledge on various mobile services making them very capable in providing feedback and suggestions. *Third*, the development and update of mobile services on average is easy, quick and requires much less resources than traditional product or software innovation. This allows for a broad range of experience in a short period of time and the application of a standardized evaluation and development approach without being subject to heavy changes in the company's market environment. The applied Kano model and its formal description by Buhl et al. (2007) build the methodological basis for our work. After describing the research methodology used, we introduce the mathematical optimization model and illustrate its practical utility with an example based on real world data.

Research methodology

According to the research framework of Meredith et al. (1989), research activities have to fit in an iterative cycle of description, explanation and testing. Our contribution shall correspond to the first two phases, the description and explanation of an observable economic fact. Since some new research insights cannot always be derived from observations in practice, a formal-deductive approach can be used. Testing the discovered insights according to its prognosis robustness shall be subject to future empirical research. For that, our approach aims at providing a basis for deriving hypothesis for empiricism. As a first step towards this direction, we will use a simplified practical example on the basis of real world data to illustrate our model's utility.

Setting and assumptions

We consider a company which aims on integrating customers in the idea generation process for a mobile service. For this purpose, different OI activities for active customer integration like mobile idea communities, mobile service prototypes, mobile app idea competitions, lead user workshops etc. are available to the company (Zogaj &

Brettschneider, 2012). As our model's scope is the optimal investment amount in OI activities, we do not focus on single OI activities with different principles of operation, but on the optimal investment amount $I^* > 0$ to be spent on a sum of OI activities with the objective to maximize the company's profit. We aim at formalizing the impact of OI activities on customer satisfaction and hence, the company's revenue. As we use a formal-deductive mathematical approach, we refer to Hevner et al. (2004, p.88), who stated that in order to "[…] be mathematically rigorous, important parts of the problem may be abstracted". This consequently implicates assumptions that we state in the following.

Assumption 1: Taken alone, all available OI activities are equal regarding their positive impact on the over-fulfillment of customer expectations and the therefore necessary payout. OI activities are divisible and can be executed separately and independently.

Though we can find weak evidence in literature (Zogaj & Brettschneider, 2012) for this simplifying assumption 1, we can state that our model's results are also valid for scenarios where OI activities have differing impact. In this case, the company would conduct the OI activities in descending order sorted by the ratio "impact on the over-fulfillment of customer expectations/payouts". As a result of assumption 1, the investment amount in OI activities has a positive linear influence on the over-fulfillment of customer expectations. Consequently, we substitute the qualitative determinant of customer satisfaction (*over-fulfillment of customer expectations*) of the Kano model by a quantitative measurable determinant (*investments in OI activities*) and focus on the specific impact of OI on customer satisfaction. Considering not a single OI activity taken alone, but several OI activities, we have to account for the Kano model and the subsiding effect of OI activities. In this vein, we can model the relationship between OI activities and customer satisfaction, which is stated in assumption 2:

Assumption 2: Investments in OI activities influence customer satisfaction in different manner (i.e. changing between convex and concave sections). To model the different impact of OI activities on customer satisfaction, we arrange Kano's attributes of customer satisfaction in descending order (i.e. attractive attributes → one-dimensional attributes → must-be attributes) and extend it by rejection through customers with regard to the respective amount of money invested.

Figure IV.4 illustrates the influence of the investment amount in OI activities I on customer satisfaction as a curve $cs(I)$. Due to the different positive as well as negative impacts of OI activities on customer satisfaction, the function on the one hand inherits a convex section where OI activities lead to attractive attributes (section 1). The function in section 2 shows a proportional progress, when OI activities only produce one-dimensional attributes and concave progress in section 3, when OI activities only produce must-be attributes due to too much customer integration (Buhl et al., 2007). The negative effect of OI activities is illustrated in section 4 where additional OI activities even lead to a decreasing progress due to rejection of the customers.

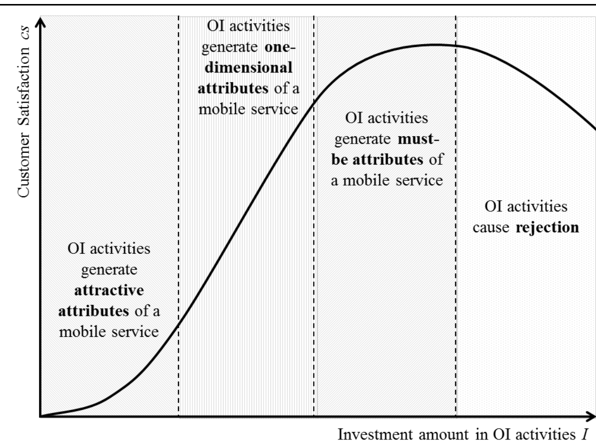

Figure IV.4: The different effects of OI on customer satisfaction.

To model all described positive and negative effects of OI, we need a formal description for $cs(I)$. One possible function to model the curve shape pictured in Figure IV.4 adequately is the so called classic earnings function from production theory (Wöhe & Döring, 2002). This function which originally aims at mathematical relations of partial factor variation is a scientifically acknowledged way to accurately describe the relation between an input factor (here: the investment amount in OI activities I) and earnings (here: customer satisfaction cs). In its general form, the function is transferable to other application fields than production theory. By using the classic earnings function, we can consider all aforementioned effects of OI. We state assumption 3.

Assumption 3: The effect of the investment amount in OI activities I on customer satisfaction cs follows a classic earnings function in the following form:

$cs(I) = -a \cdot I^3 + b \cdot I^2 + c \cdot I + cs_0$ with $a, b, c > 0$

The parameter $cs_0 > 0$ thereby guarantees that a company not investing in OI activities in mobile service development at all will end up at a basic but positive customer satisfaction level. The parameters a, b, and c are necessary to model the changing course gradient and curvature progression of the customer satisfaction curve as seen in Figure IV.4. In order to reach a decision model with economic parameters, we have to consider that investing in OI activities influences customer satisfaction and, eventually, the financial performance of the company (Buhl et al., 2007; Gupta et al., 2006, Mittal et al., 2005). Since we do not focus on the monetary valuation of customer satisfaction, we state the simplifying assumption 4.

Assumption 4: A company's revenue originating from mobile services $r(cs(I))$ for a considered period of time equals the customer satisfaction achieved by investing in OI activities multiplied by the conversion factor $d > 0$. Other influences are neglected.

Assuming a linear correlation between customer satisfaction and a company's revenue from mobile service innovations by all means is simplifying matter. Nevertheless, we refer to the work of Mittal et al. (2005, p.544) who state that "[…] the association between customer satisfaction and long-term financial performance is positive […]". They emphasize this correlation to be stronger in case companies are able to simultaneously increase customer satisfaction *and* decrease costs at the same time. As OI activities through enhanced innovation processes and more customer oriented products increase customer satisfaction and also partly support cost reduction (at least in the long-term), they indirectly are able to contribute (weakly) to both goals as shown by Faems et al. (2010). Thus, we can state this simplifying assumption without distorting reality and our model's results too much. In case a company's revenue stands in other than a linear relation to customer satisfaction, e.g. convex, concave, relations, the model could easily be tailored to such other relations by adapting the factor d to be a function of $cs(I)$. However, empirically examining the association between customer satisfaction through OI activities is still due to further research. We incorporate this simplifying correlation by formalizing the company's revenue by

$r(cs(I)) = cs(I) \cdot d$. In order to come to a decision model, we state our last assumption 5.

Assumption 5: The company's major objective is to maximize its profit $P(I)$. For reasons of simplicity, all parameters are assumed to be deterministic and the time value of money is neglected.

Neglecting the time value of money is simplifying matters but reasonable due to the short time periods of innovation processes and market penetration with mobile services. On the basis of these assumptions and the presented profit function we in the following are able to determine the optimal investment amount in OI activities. The company evaluates the economic utility of OI activities on the basis of the profit function, which is thereby also the function to be optimized: $P(I) = r(cs(I)) - I$

By including the revenue function and the classic earnings function in the profit function $P(I)$, we can derive the final objective function for investments in OI:

$$P(I) = r(cs(I)) - I = \mathrm{cs(I)} \cdot d - I = (-a \cdot I^3 + b \cdot I^2 + c \cdot I + cs_0) \cdot d - I \to max!$$

In order to determine the optimal investment amount in OI activities, we maximize the objective function by setting the first derivative of $P(I)$ equal to zero.

$$\frac{\partial P(I)}{\partial I} = -3 \cdot a \cdot d \cdot I^2 + 2 \cdot b \cdot d \cdot I + c \cdot d - 1 = 0$$

By solving this term for I, we get two candidates $\breve{I}_1$, $\breve{I}_2$ for the maximization of the objective function. Under the given assumptions it is easy to show that only

$$\breve{I}_1 = \frac{bd + \sqrt{-3ad + b^2d^2 + 3acd^2}}{3ad} \quad \text{implies} \quad \frac{\partial^2 P(\breve{I}_1)}{\partial^2 \breve{I}_1} = 2 \cdot b \cdot d - 6 \cdot a \cdot d \cdot I < 0$$

and therefore $\breve{I}_1$ remains as the only candidate. Given that $\breve{I}_1$ is in the assumed domain ($\breve{I}_1 > 0$) and $P(\breve{I}_1) > 0$, $\breve{I}_1 = I^*$, which is the optimal investment amount in OI activities maximizing the company's profit under the given assumptions. In case $P(\breve{I}_1) < 0$, $I^* = 0$. Consequently, it is reasonable to raise the investment amount up to I^*. Investments in OI activities with $I < I^*$ do not maximize the company value. Thus, an increase of the investment amount in OI activities leads to an increased over-fulfillment of customer expectations and, hence, customer satisfaction. In contrast, the positive effects of investments in OI activities with $I > I^*$ in fact still exceed the initial payouts.

However, the subsiding effect of OI activities on customer satisfaction leads to disproportionally high capital expenditures and to less additional customer satisfaction.

IV.5 Practical Example with Real World Data Basis

We demonstrate our model's practical utility with the data of a large manufacturing company of a current industry (research-in-progress) project in the context of mobile app innovations. The company is developing several mobile apps for its customers and sales representatives. The company has already performed OI activities and now wants to decide on the investment amount to be spent on an OI activity for its next mobile app projects. With regard to the company's experience with OI, the company has tracked occurred payouts of five already completed OI activities from the past mobile app projects. With the help of the user statistics of the already implemented mobile apps emerged from the OI activities, the company is able to estimate values for productivity increase, realized cross selling potential, brand value and revenue increase and other benefits of two mobile service innovations. Moreover, the company can use a quantitative estimation method to estimate the financial benefits of the ideas generated by the three other OI activities (Tversky & Kahneman, 1974). This is done by estimating payouts and intervals for financial benefits through the responsible business experts. By aggregating these figures to project values and summing them up, the company is able to determine values for payouts and profits of the OI activities in mobile app development projects which can be seen in Table IV.1. Project risk is obviously no issue here, which is subject to further research. The values for payouts include payouts for the actual execution of the OI activity, but also for preparation, conceptualization, the processing of results including the description and evaluation of ideas emerged from the respective OI activities. Due to the confidential character of the data, all values were transformed.

Table IV.1: Input values for the practical example

OI activity	Description	Payouts I	(estimated) profit $P(I)$
1st	Lead user interviews 1	45 thousand (T)€	0.5 T€
2nd	Lead user interviews 2	20 T€	8 T€
3rd	Field observation	25 T€	49.25 T€
4th	Online survey	60 T€	168.25 T€
5th	Idea competition	100 T€	290 T€

By using the values from Table IV.1 in the profit function $P(I)$, a linear system of five equations with five unknown variables comes into being. Thus, the company is able to determine the values for the objective function ($a = 0.01$, $b = 5$, $c = 1$, $d = 0.005$ and $cs_0 = 50$). For the next investment amount on OI activities we can find the overall optimum to be $I^* =$ *312,078 €* resulting in a maximized profit of $P(I^*) =$*604,844 €*. Thus, it makes good economic sense for the company to invest this overall amount of money in OI activities. Below or above this amount, the over-fulfillment of customer expectations is lower, customer satisfaction decreases and revenue is below the maximum. In this example, investing more than the economic optimum will lead to worse results than investing an equal amount less, e.g. an investment sum of $I =$250*,000 €* (*-62,078 €* less the optimum) will result in 532*,750 €* profits, whereas an investment sum of $I =$*374,156 €* (*+62,078 €* more than the optimum) will only generate *508,827 €* profit. Investing more than *456,424 €* will even lead to losses, since the continuous OI activities lead to customer dissatisfaction. Since the company already invested *250,000 €* for the OI activities above in sum, the recommendation for the management is to invest another *62,078 €* to reach the optimum I^* with the next OI activity. Above this amount of money, it is not reasonable to invest more in OI activities. However, in practice, the calculated optimum from our theoretical model cannot be assumed to be exactly valid. The calculated optimum should therefore be interpreted as an indicator for a range for the next investment in OI activities rather than an exact number. In order to refine the results, experimental projects regarding investments in OI activities in mobile service development and refining the input values for the objective function is advisable. This holds especially true with regard to the fact that the values of the objective function may change over time due to influences like a dynamic competitive environment, company restructuring or scale and learning effects. For this reason, we suggest not to rely on a unique determination of the optimal investment amount in OI activities but to stress the input values on a regular basis and update the data basis with current project data.

IV.6 Conclusion and Outlook

Mobile service innovations' potential for valuable economic impact attracts companies to conduct significant investments. To develop and launch successful mobile services, integrating customers in the idea generation process through OI activities bears high potential and is hence desirable. However, the lack of a precise analysis of the relation between OI investments and generated revenues leads to a lack of well-founded economic decisions regarding investments in OI activities. This paper aims at replacing the black box between OI investments and revenue with an effect chain. We formalized the effect chain putting special emphasis on the specifics of mobile services and represented the effects of OI with a flattening curve assembled from the attributes of customer satisfaction of the Kano model regarding mobile services. Through mathematical optimization, we aim at determining the optimal investment amount in OI activities and show the model's utility with an example based on real world data. Nevertheless, several restricting assumptions and resulting conditions of this paper have to be examined critically. First, the relation between OI investments and the over-fulfillment of customer expectations must be examined in more depth in order to calibrate the model to practice thus guaranteeing valid outcomes. Second, Peppers and Rogers (2001) note that the success of OI depends on the quality of information that is gained by customer integration. Thus, it is necessary to distinguish between different kinds of OI activities and integrate them in the model. Third, all factors of the model are considered to be deterministic. Due to the high dynamics of the domain, it is likely that the estimation of parameters necessary for the objective function is quite demanding. The enhancement of the model to a decision calculus considering risk therefore requires further research. Fourth, though the model formalizes the effect of customer integration in an economic model, it is necessary to validate all assumptions and the effect chain by testing through empiricism. However, the model presents a starting point for further research on the economic effects of customer integration in mobile service development to take full advantage of the high potentials of OI in mobile industries.

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V Summary and Future Research

In this chapter, the key findings of the dissertation are summarized (section V.1) and potential starting points for future research are presented (section V.2).

V.1 Summary

This dissertation's main objective was contributing to the field of IT innovation research by particularly focusing on the phenomenon of fashionable IT innovations. After emphasizing the importance of dealing with the fashion phenomenon in IT innovation research and the necessity of a well-founded evaluation for a mindful IT innovation strategy, the dissertation's focus was on the ex ante evaluation of an engagement in fashionable IT innovations. Particularly, the research papers focused on the idiosyncrasies which come along with IT innovations within their fashionable phase and emphasized the consideration of risk and return. As this forms a gap in previous IT innovation and IT fashion research, it is from major interest for both, research and practice. In the following, the key findings of the research papers that are included in this dissertation are summarized before at the end, future research opportunities are discussed.

- Chapter II had two major objectives: First, the relevance of research which deals with the ex ante evaluation of an engagement in fashionable IT innovations should be motivated. Second, it illustrated the major characteristics of fashionable IT innovations, possible paths of evolution and how risk and return have to be considered regarding different IT innovation strategies. On the basis of an extensive overview on previous IT innovation and IT fashion literature, the paper emphasized the ex ante evaluation of an engagement in fashionable IT innovations as a major research gap in this research field. Consequently, the emergence of a fashionable IT innovation, its potential path of evolution (long-term institutionalization vs. getting stranded) and how this affects risk and return of different IT innovation strategies was illustrated on a conceptual basis. To set the basis for later research which aims at ex ante evaluation for decision making, major challenges for the evaluation were discussed in a first step.

Thereafter, seven characteristics of emerging technologies that can influence a fashionable IT innovation's probability of institutionalization and thus the extent of risk and return regarding the engagement were analyzed and critically discussed. Hence, the findings of chapter II conceptually set the basis for the development of theoretical models which support the ex ante decision making of an engagement in fashionable IT innovations to support mindfulness in an IT innovation strategy.

On the conceptual basis of chapter II, three theoretical models for the ex ante decision making regarding the engagement in fashionable IT innovations were proposed in chapter III. They aim at the evaluation of a single IT innovation investment by integrating long- and short-term implications (section III.1), the evaluation of an engagement in fashionable IT innovations in a one-period IT innovation portfolio scenario (section III.2) and the evaluation of an engagement in fashionable IT innovations in a two-period scenario by simultaneously analyzing the impact of rule-of-thumb decisions.

- In section III.1, the first objective was to generally distinguish investments in IT innovations and normal IT objects like the replacement of a server. Thereby, an IT innovation investment's long- and short-term impact, its risk as well as its potential interdependencies with the existing IT portfolio were emphasized as the major distinguishing characteristics that need to be addressed within the evaluation. Consequently, an approach for the evaluation of single IT innovation investments that considers these characteristics was developed. The approach thereby combines the well-established method of a risk adjusted Net Present Value (NPV) and the With and Without principle and so allows for an ex ante evaluation that integrates a company's long- and short-term objectives, the IT innovation's risks as well as interdependencies with the existing IT portfolio. On the basis of a real world example, the approach's practical applicability was demonstrated and also analyzed via a sensitivity analysis. The latter revealed the importance of an integrated long- and short-term view on the advantageousness of the engagement in IT innovations. The sensitivity analysis also outlined that both, the risk of a single IT innovation as well as the risk of the existing IT portfolio are of major relevance within the evaluation of an engagement in IT innovations when considering interdependencies. Thus, section III.1 pointed out that companies in practice are well-advised by taking into account the long- and short-term perspective as well as the risk of a new single IT innovation and the risk position of the IT portfolio (i.e., stability of the existing processes and applications) within the ex ante evaluation.

- Section III.2 extended the perspective of the previous section and aimed at an IT innovation portfolio approach which distinguishes between the engagement in fashionable and non-fashionable IT innovations. The section's focus was on the high risk and high return potential which is associated with the engagement in fashionable IT innovations. As this idiosyncrasy of fashionable IT innovations influences the optimal share of an IT innovation portfolio that is dedicated to different types of IT innovations, the goal of the research paper in section III.2 was answering the following central research questions: First, what is the impact of an engagement in risky fashionable IT innovations on an IT innovation portfolio's risk as well as its value when regarding risk and return? Second, what is the optimal share of engagement in fashionable IT innovations within an IT innovation portfolio considering risk and return? By applying modern portfolio theory and decision making theory in the context of fashionable IT innovations, the research paper in section III.2 transferred well-established theories to a new emerging field of research and thus contributed to the IT innovation and IT fashion literature by simultaneously providing a practical approach for mindful decision making. The main findings of section III.2 were the following: First, the engagement in fashionable IT innovations can contribute to minimize the IT innovation portfolio's risk even though it has to be considered as very risky. Second, it can contribute to maximize an IT innovation portfolio's value when considering risk and return. Third, when considering the engagement in fashionable IT innovations within an IT innovation portfolio, the decision maker in particularly has to consider the fashionable IT innovation's risk/return ratio, the correlation to non-fashionable IT innovations and the impact of the decision maker's risk aversion. All those parameters substantially influence the advantage in a way that there exists an upper as well as a lower boundary for the engagement which is beneficial for the IT innovation portfolio.

- Section III.3 took the major findings of the previous sections up and – by applying an IT innovation portfolio perspective – also aimed at allocating the IT innovation portfolio's budget optimally to fashionable and non-fashionable IT innovations. In contrast to section III.2, the research paper in section III.3 applied a two-period scenario and thus focused on a fashionable IT innovation's risk of not getting institutionalized over its lifecycle as its first research question. The first contribution thus was the development of a dynamic optimization model which optimizes the allocation of an IT innovation portfolio's budget to fashionable and non-fashionable IT innovations. By applying simulation as evaluation method, the research paper in this section on average found a theoretical optimal engagement in fashionable IT innovations of about 16% – a value which fits quite well with the findings of empirical research in this field that examined how much successful companies invest in new emerging IT (Nagji & Tuff, 2012; Ross & Beath, 2002). In addition, section III.3 emphasized the importance of a steady engagement in fashionable IT innovations and aimed at answering a second central research question which deals with the error of systemic under- or overinvestments in fashionable IT innovations. The results of section III.3 revealed that a systematic underinvestment in non-fashionable IT innovations in favor of fashionable IT innovations leads to a substantial higher damage compared to an IT innovation strategy which tends to neglect the engagement in fashionable IT innovations. However, section III.3 also revealed that an IT innovation strategy which systematically neglects the engagement in fashionable IT innovations is more risky and thus results in higher damage as an IT innovation strategy which systematically overemphasizes an engagement in fashionable IT innovations compared to the theoretical optimum. Thus, section III.3 supported and strengthened the results of the previous sections.

Summarizing chapter III, we can conclude that the engagement in fashionable IT innovations can be beneficial for companies and thus support previous findings by Wang (2010) or Stratopoulos and Lim (2010). However, the research paper within this section also revealed the importance of incorporating several idiosyncrasies of fashionable IT innovations within the ex ante evaluation of such an engagement to avoid gut feeling decisions.

In contrast to the research papers in the chapters II and III which did not focus on a certain fashionable IT innovation or innovation concept, the focus of chapter IV was on a specific technology (mobile service technology) and also took up a rather new innovation management concept which is called Open Innovation (Chesbrough, 2003). The major focus of this chapter thus was to demonstrate Open Innovation as a suitable approach to develop successful IT innovations. Whereas the previous chapters aimed at the evaluation of fashionable IT innovations which already exist outside a company, chapter IV aimed at evaluating the cause-and-effect chain between investments in Open Innovation activities (e.g., lead user interviews) for the company-inside development of innovative mobile services and the economic profit which results from these mobile services. Open Innovation is a rather new and by all means fashionable topic in IT innovation research whose literature mainly is focused on empirical and case-study based work (Schroll & Mild, 2012; van de Vrande et al., 2010). Though it is well-accepted that Open Innovation can lead to products and services which meet the customer needs better and thus increases the company's revenue (Faems et al., 2010), the precise relation between Open Innovation activities and economic profit is indistinct. Thus, the research paper in chapter IV developed a formal-mathematical model that examines the relation between investments in Open Innovation activities, customer expectations, customer satisfaction and company profit by particularly focusing on mobile service technology innovations as an example of a former fashionable IT innovations. By applying the theoretical model in the context of a real world decision problem, an optimal investment amount in Open Innovation activities was derived which could serve as a guidance for the decision making in practice to avoid gut-feeling and overhasty Open Innovation activities.

Taking the major findings of the research papers within chapter II, III, and IV together it can be concluded that this dissertation contributed to the existing literature in IT innovation research by its particular focus on the phenomenon of fashionable IT innovations. Especially, it complements previous research by explicitly developing ex ante decision models that allow for evaluating the engagement in fashionable

IT innovations mindfully and thus can contribute to less bandwagon behavior and gut feeling decisions. However, despite the presented findings and the contribution to the literature, there remain further methodological and contextual challenges which offer starting points for future research.

V.2 Future Research

In the following, potential aspects for future research are highlighted for all research papers that are included in the chapters or sections of this dissertation.

- The description of the characteristics and the evolution of fashionable IT innovations in chapter II did not intend to provide a complete guidance on how to engage in fashionable IT innovations considering risk and return. Rather, it aimed at serving as a conceptual basis for the research papers which followed in the chapters III and IV. However, even on a conceptual basis, there is still room for further research that deals with the question on whether, when, and to which extent the engagement in fashionable IT innovations are beneficial:

  1. The conceptual description of the characteristics that might influence institutionalization and thus the risk and return extent of different IT innovations strategies is limited as it lacks empirical evidence. Thus, further research empirically could examine which characteristics influence the probability of institutionalization. Wang (2010) as well as Baskerville and Myers (2009) already provide overviews on the fashionable phase of certain IT innovations which might serve as a starting point.

  2. Though the conceptualization of how risk and return are to consider for different IT innovation strategies serves as a general guidance for decision makers when it comes to the engagement in fashionable IT innovations, it does not draw a distinction between industries, company size, or general attitudes towards innovation. Whether some companies regard IT innovations as their core business model, some only use IT as basic instrument. A first step in this direction was made by Lu and Ramamurthy (2010) who examined the

advantageousness of different IT innovation strategies by particularly differentiating between companies in a dynamic or stable industry environment.

3. Even though the conceptualization of risk and return in different IT innovation strategies allows for a more mindful decision regarding the engagement in fashionable IT innovations, it does not enable predicting the next big thing. Though serious research never should presume to develop models which allow for predicting the technology that turns out to change the game, the incorporation of a decision maker's ability to predict the next big thing might be an interesting field of research as first research by Denrell and Fang (2010) has shown.

- The integrated long- and short-term valuation of IT innovation investments as presented in section III.1 is a first step regarding the question of whether to invest in a single IT innovation or to prioritize different IT innovation possibilities. However, selecting and valuating the IT innovation which is suitable for the company on the basis of this approach requires some advancements before it can be applied in practice:

1. Weighting an IT innovation's long- and short-term impact on the basis of a single weighting parameter allows for manipulations due to different interests regarding the company policies. Thus, further research which condenses the company's long- and short-term objectives within a weighing parameter that does not allow for manipulation would be a valuable endorsement to the presented approach.

2. Though the approach presented in the respective research paper considers an IT innovation's impact on the existing IT portfolio, it neglects the implications on other business units like marketing, finance, or production planning. This limits the practical utility as even if an IT innovation might not provide a positive value contribution for the existing IT portfolio, it could serve as a platform which is beneficial for other business units in sense of a real option as examined by several authors like Kauffman and Li (2005).

- In contrast to section III.1 which has focused on the evaluation of a single IT innovation, the respective research paper in III.2 extends the view on the entire IT innovation portfolio in a one-period scenario. However, this comes along with the following limitations that could be addressed in further research:

  1. The application of modern portfolio theory for the evaluation of an engagement in fashionable IT innovations as presented in III.2 requires rather restrictive assumptions, simplifications, and the challenge of estimating the values of major input parameters like expected NPV or correlations. To enable direct transfer to practice, further research could focus on the empirical examination of interrelations between the returns from fashionable and non-fashionable IT innovations. Therefore, previous work like Wang (2010) could serve as a starting point to determine the expected returns, variances etc.

  2. The application of modern portfolio theory as applied in section III.2 does not incorporate important aspects like the evolution of a fashionable IT innovation over time or the company's ability to innovate with new emerging IT (Fichman, 2004; Robey et al., 2000). Though the research paper which follows in section III.3 is a first step in this direction, there is still room for further research which particularly applies modern portfolio theory and decision making theory which is able to address the decision maker's risk attitude adequately.

- Though the research paper in section III.3 takes up some major idiosyncrasies regarding the engagement in fashionable IT innovations that have been neglected within the previous sections (e.g., particularly examining the lifecycle of an IT innovation or a company's ability to innovate with IT), the theoretical optimization and evaluation via simulation still bears potential for further research to enrich IT innovation literature with regard to this specific topic:

  1. The company's individual innovator profile which depicts the ability to innovate with IT is assumed to be constant over time. However, various researchers emphasized the importance of organizational learning within the IT innovation process as a major determinant of a company's ability to innovate with IT (Ashworth et al., 2004; Fichman & Kemerer, 1997; Salaway, 1987;

Tippins & Sohi, 2003; Wang & Ramiller, 2009). Hence, the incorporation of organizational learning which impacts the company's individual innovator profile over time might be a valuable topic in further research.

2. Though the illustration of an IT innovation's lifecycle via a two-period optimization model as presented in section III.3 is a first valuable step, extending the time frame and applying a n-period model might be a promising approach to examine the idiosyncrasies of the IT innovation lifecycle in more detail. In particular, modeling the emergence of new fashionable IT innovations over a specific period of time and thus examining spill-over effects which result from the learning in earlier periods might contribute to the incorporation of organizational learning in IT fashion research.

3. Whereas the model's evaluation via simulation on the one hand is a well-accepted method to derive first results, it also requires determining the input parameter's range and distribution which might limit generalizability. Thus, further research that empirically examines potential values and distributions for core parameters like a fashionable IT innovation's probability of institutionalization (see also aspects for further research regarding chapter II) might be a valuable contribution for future research.

- The relentless success of mobile service technology and Open Innovation requires a wide range of future research that deals with the ex ante evaluation of an engagement in Open Innovation to avoid mindless integration of external partners without a well-founded analysis. On the basis of the findings in chapter V, the following aspects can serve as starting points for further research:

  1. The positive relationship between Open Innovation and the over-fulfillment of customer expectations as assumed in chapter V requires further empirical work which examines whether this relation can be assumed generally, is applicable only for certain Open Innovation activities, or cannot be assumed when applying Open Innovation in the innovation process regarding different products or services.

2. Though chapter V assumes all Open Innovation activities to have the same effect on over-fulfilling customer expectations, literature emphasizes the diverging appropriateness of Open Innovation activities for different kinds of companies, products and service innovations as well as groups of external partners (Zogaj & Brettschneider, 2012). Thus, modeling the effect of certain Open innovation activities differently would be a promising aspect in future research.

3. Previous literature has emphasized that applying Open Innovation within different phases of the (IT) innovation process differently impacts the innovation contribution as well as the risks that come along with such activities, (Enkel et al., 2005). Hence, a differentiation of Open Innovation activities within the different (IT) innovation process phases which for reasons of simplicity was neglected in chapter V might be a promising aspect for future research.

Taken together, the research papers presented in this dissertation contribute to the ex ante evaluation of the engagement in fashionable IT innovations – a topic with increased attention within IT innovation research and practice since a decade (Baskerville & Myers, 2009; Gill & Bhattacherjee, 2009; Myers et al., 2010). Though the dissertation could not answer all questions and challenges that come along with fashionable IT innovations, it complements previous literature with methods that allow for an ex ante decision making and thus contributes to more mindfulness which is the fact when a company engages in fashionable IT innovations "[…] with reasoning grounded in its own organizational facts and specifics." (Swanson & Ramiller, 2004, p. 559). As IT innovations will also play a major role for companies within the next decades it is hoped that this dissertation can provide companies and researchers with methods that incorporate company facts and specifics. By that, it could help to evaluate the engagement in fashionable IT innovations with reasoning grounded by considering their risk and return adequately and so put research "[…] among the leaders, and not just the followers, of fashion." (Baskerville & Myers, 2009, p. 661).

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