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RESEARCH PAPER

The Business Value of IT in Light of Prospect Theory

A New Explanation for IT Paradoxes

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Abstract A key problem with IT decision-making is that the real value contributions of IT projects are unknown ex-ante to their executions. Thus, an organization has to rely on the expectations and perceptions of its decision makers. Moreover, these perceptions are prone to biases and display only a transfigured or irrational image of reality. This paper examines how these biases are related to the business value of IT (BVIT) and how IT decision-making can be rationalized. To this aim, a model is set up based on prospect theory, which is a frequently cited theory from behavioral economics used to descriptively analyze human value perception under risk. Applying the results found via prospect theory to IT decisions, the "perceived" BVIT is quantified and analyzed. Based on the model, the paper shows that the irrationalities rooted in human value perception provide explanations for two central paradoxes of IT. First, it reveals that they cause a disparity between the anticipated value-adding effects of IT and the actual measured outcomes, reflecting a famous observation within BVIT research known as the "productivity paradox of IT." Second, recent studies show that IT increases the operational efficiency and competitiveness of organizations. However, only the operational effects are perceived in practice. In the paper, this one-sided perception is referred to as the "perception paradox of IT". It is ultimately concluded that a rethinking of the position of IT within modern organizations and the establishment of suitable corporate governance mechanisms can resolve these issues, avoid irrationalities, and positively influence the performance impacts of IT.

Keywords Business value of IT · Perceived value of IT · Prospect theory · Productivity paradox

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1 Introduction

The globalization of today's economy has increased the competitive pressure on organizations. Companies must be able to react rapidly to changing customer needs or to technological innovations. Correspondingly, the role of IT "as a powerful competitive weapon" for encountering these challenges is becoming increasingly important, and every IT investment has to be critically evaluated with respect to the business value created (Mata et al. 1995, p. 487). This business value of IT (BVIT) is defined "as the organizational performance impacts of IT at both the intermediate process level and the organization wide level, and comprising both efficiency impacts and competitive impacts" (Melville et al. 2004, p. 287). A key problem for IT decision-making is that the value contributions of IT projects are unknown in the decision process; thus, the decision makers' perceptions of the projects are determinate. A characterization of the abstract term "perception" in cognitive psychology is the sensory experience of the environment, which involves the recognition and the interpretation of external information (Cherry 2013). Thus, we define the perceived BVIT as the decision makers' mental interpretation of IT performance impacts. A key

problem with human value perception is that it is based on heuristics and prone to biases (Gilovich et al. 2002). Such mental shortcuts within human valuation processing lead to deviations between the IT value perceived by decision makers and the objective IT value, and, ultimately, to irrational IT decisions.

The analysis of the perceived BVIT enables us to determine where these heuristics originate and how IT decision-making can be made rational. For example, we can derive solutions for the productivity and the perception paradoxes of IT. The productivity paradox refers to the observation that most IT investments fall short of their expected performance effects (Brynjolfsson 1993). In other words, decision makers misperceive the BVIT. The perception paradox refers to the perceived value sources of IT. In general, the performance effects of IT can be divided into two categories: productivity and competitive effects (Melville et al. 2004). Productivity relates to internal value and is manifested in the reduction of operational costs (Drucker 1966). Competitive effects are associated with external value and typically show in competitive advantages (Barney 1991). In practice, however, it is mainly the internal value of IT that is perceived. In a global CFO technology study by Gartner (2013), only 10 % of the respondents considered IT as a potential source of differentiation, whereas 31 % perceived the value of IT in the enhancing of operations. Many researchers have promoted the role of IT as a source of competitive advantage and the need for investment in that type of IT (Devaraj and Kohli 2003; Santhanam and Hartono 2003). However, despite the considerable successes of such investments in the past, this facet of IT value has only partly influenced the minds of practical decision makers. We refer to this one-sided perception as the "perception paradox" of IT.

In this paper, we utilize the value perception of practical decision makers as an innovative, analytical lens with which to examine the BVIT. In order to investigate the effects of the described irrationalities of IT decisions, we develop an analytical model for the human perception of IT value based on the famous prospect theory (PT) from Kahneman and Tversky (1979). They formulate a quantification of human value perception that incorporates several common patterns (e.g., loss aversion or asymmetric risk attitudes) frequently demonstrated in behavioral experiments. The application of their framework has already been beneficial for other economic research streams, especially capital market theory (De Giorgi and Hens 2006). Therefore, it may also be useful in deriving new insights for BVIT research. Although PT was originally designed for individual decision-making, it is at least partially applicable for corporate decision-making, as is the case for IT decisions. The perceived value function from PT remains valid for organizational value perception if the context of the organization is considered (Shimizu 2007) and if it is parameterized differently (Wen 2010). Investigating the BVIT through the "irrational" eyes of PT introduces a new research perspective that can complement, confirm, and enhance existing research results. The contribution of this paper is to provide a descriptive, analytical model of the perceived BVIT through which we can shed light on resolutions of the paradoxes of the BVIT.

The remainder of this article is structured as follows: In the next section, we describe the fundamental theoretical concepts that our perception model is based on to substantiate the existing research gap. Then, we analyze the foundations of the described paradoxes of IT, and apply the derived results to obtain additional explanations for their existence. Finally, we discuss our results and provide an outlook on future research.

2 Theoretical Background

2.1 The Business Value of IT

In the 1960s and 1970s, information technology (IT) was perceived as the "biggest technological revolution men have known" (Snow 1966, p. 650). However, the technology could not meet these high expectations. As a result, a great disillusionment with IT arose in the 1980s. During this time, economic productivity stagnated, while the number of computers increased more than threefold (Brynjolfsson 1993). Moreover, the first scientific studies about the realized value of IT provided controversial results and thus exacerbated doubts about technology (Yorukoglu 1998). Even Nobel Laureate Robert Solow addressed the productivity shortfall of IT investments, which became known as the "productivity paradox," in his famous quote: "We see computers everywhere except in the productivity statistics" (cited after Brynjolfsson 1993, p. 67). The value discussion finally reached its climax in 2003, with Nicholas Carr's aggressive article "IT Doesn't Matter" (Carr 2003). In this article, Carr argues that IT shows the basic characteristics of infrastructure technologies and, therefore, cannot be a source of competitive advantage. The productivity paradox and the heated debate about the BVIT endangered the position of the information systems research community. Consequently, scholars established the BVIT research stream to focus on the "how's" and "why's" of IT value creation within a firm or a network of firms (Kohli and Grover 2008). The scientific objective is basically "to fully capture and properly attribute the value generated by IT investments" (Kohli and Grover 2008, p. 27). Indeed, the scientific efforts of the research stream have been successful. Today, the existence of the BVIT is increasingly becoming accepted (Kohli and

Grover 2008; Hu and Quan 2005; Kudyba and Diwan 2002; Thatcher and Oliver 2001; Lee and Menon 2000). Nevertheless, the value proposition of IT is challenged again and again, as evident in articles such as "The CIO Dilemma," published by the trading magazine *InformationWeek*, in which the diminishing role of CIOs is described and the failure of IT to deliver innovations is condemned (Martin 2007). Scientific discourses and recurring debates have kept the research discipline up-to-date and fascinating for the last 30 years, and its research questions are still considered understudied (Kohli and Grover 2008).

Before differentiating the objective from the perceived value of IT, we start with defining the abstract terms IT and BVIT. Within BVIT research, IT is often mentioned together with information (and communication) systems (IS), and often these terms are not clearly distinguished. Therefore, this paper employs a comprehensive understanding of IT, utilizing the abbreviation to reference various technology classes, such as enterprise architectures, databases, software applications, servers, networks, and other infrastructure components. Combining the economic concept of value and the comprehensive understanding of IT leads to the concept of the BVIT, which is defined as "the organizational performance impacts of IT at both the intermediate process level and the organization-wide level, and comprising both efficiency impacts and competitive impacts" (Melville et al. 2004, p. 287). A special attribute of these effects is that they can be realized in multiple strategic dimensions. Similar to Weill and Vitale (1999), Oh and Pinsonneault (2007) describe a framework where the value of IT is classified into three strategic effect types. IT investments can aim at minimizing "operational costs while maintaining a satisfactory level of quality," "providing a unique combination of product attributes at a reasonable cost," or increasing the sales volume of organizations (Oh and Pinsonneault 2007, p. 245). In other words, IT investments are intended to increase the revenues or reduce the costs of an organization. Investments that increase the sales volume and provide a higher degree of product differentiation affect the firm's revenues, defined as the product of the sales volume and sales price. Increased sales volume contributes directly to revenues, and increased product differentiation can typically be transferred into higher sales prices (Nault and Dexter 1995). We refer to IT investments that are characterized by revenue effects as revenue investments. IT investments that are aimed at reducing operational costs are defined as cost investments. The above reasoning demonstrates that IT investments typically underlie an ambiguity concerning their strategic and monetary effects so far.

The perceived BVIT is the decision maker's mental interpretation of IT performance effects, and represents the expectations for the technology ex-ante to the investment. Thus, it serves as a kind of filter for IT investment opportunities. Only those IT projects that are perceived as highly valuable will be put into practice. Consider a decision about the implementation of a new ERP system, where different software suppliers offer their product and a firm has to choose its favorite. The firm will choose the software with the highest perceived business value. Only the chosen ERP system can create real performance effects for the firm, and the other decision alternatives never create any BVIT. In other words, the perceived value constitutes the first obstacle for IT to create any business value and determines which IT projects are implemented and which are rejected. The implemented projects in turn influence the realized performance effects (i.e., the BVIT). Therefore, the perceived and the objective BVIT both refer to the same underlying construct, which is the performance effects of IT, in the given example to the performance of an ERP system. However, the irrationalities inherent in the perception process can make the implemented IT or the chosen ERP system deviate from the rational optimum. As a result, the BVIT may fall short of its potential. The identification and avoidance of irrationalities can, therefore, improve the BVIT.

The example of the ERP system illustrates the close connection between perception and reality with regard to the BVIT. However, there are important structural differences between these concepts. First, the BVIT refers to the realized economic outcome of IT investments, which includes cost reduction and revenue improvement. The perceived BVIT is about how decision makers perceive the benefits they can gain from IT investments, not about the actually realized benefits. In other words, the BVIT is a real and objective metric, whereas the perceived BVIT is a mental and subjective construct. Second, both approaches become relevant at different time points relative to the investment decision. The BVIT becomes relevant in the value chain of the organization ex-post to the decision and focuses on past developments. The perceived value is pertinent to the decision process (i.e., ex-ante to the decision), and is orientated toward the future. Third, due to its ex-post character, the BVIT is measurable and, thereby, certain. In contrast, the perceived BVIT is about future performance effects that underlie uncertainties and risks. Fourth, unlike the objective BVIT, the perceived BVIT is prone to biases and heuristics. These factors ultimately lead to deviations between the BVIT and the perceived BVIT.

Analyzing the performance effects of IT from a perceptional perspective is promising for the corresponding research stream. Performance effects are not understood as a realistic outcome but as the outcome of an economic decision within an organization. Ultimately, it is organization-specific factors, not advance perceptions that

determine how IT affects the performance of an organization. However, the particular manifestations and characteristics of the performance effects are also a consequence of an organizational decision. Therefore, it is relevant to consider not only the characteristics of IT in its role within the value chain of an organization but also its attributes within the decision process. Although the perceptional approach cannot be seen as substitutive or superior, it may contribute to a more holistic understanding of the BVIT. This research expands the spectrum of distinguishing features of IT investments.

2.2 Prospect Theory and the Quantification of Perceived Value

In order to quantify the perceived value of IT, we apply PT, which is probably the most prominent descriptive model for human value perception. In the existing IS literature, PT has been applied to explain phenomena such as the escalation of software projects (see, e.g., Keil et al. 2000), the bidding behavior of consumers in online auctions (Wu et al. 2009), and the deviations of expectations regarding technological innovations between developers and users (McAfee 2009). However, no analytical model exists that introduces PT and the related behavioral aspects to BVIT research (Fleischmann et al. 2014). The analytical approach is crucial for the derivation of reliable results from PT (Bromiley 2009). In general, PT analyzes human decision-making with respect to observable violations of expected utility theory (EUT) as a benchmark for a rational value understanding. It represents an alternative approach that complies with the observed violations. Whereas PT descriptively analyzes how human beings make decisions under risk, EUT normatively investigates how decisions under risk should be made optimally and rationally. With decisions under risk, the possible outcomes and the corresponding probabilities of occurrences for those outcomes are known. In other words, a formal representation of the decision problem is possible. In contrast, decisions under uncertainty are characterized by unknown probabilities of occurrence (Tversky and Kahneman 1981).

PT identifies four characteristics of human value perception that are not addressed in EUT. First, decision makers evaluate alternatives with respect to "gains" and "losses" relative to a given reference point. In this context, the terms gain and loss do not refer to their economic interpretation as positive or negative profits; rather, they are defined as positive or negative deviations from the reference point. Second, decision makers are characterized by loss aversion, which means that their dislike for losses is by a factor of about 2.25 higher than their fondness for gains (Kahneman and Tversky 1979). Third, decision makers have asymmetric risk attitudes, which means that they are risk-seeking toward losses and risk-averse toward gains. Fourth, the value perception is not exclusively determined by the perception of the outcomes; it is also influenced by the perception of the corresponding probabilities of occurrences for these outcomes. Human beings nonlinearly transform the probability scale by overweighting small probabilities and underweighting moderate and high probabilities in their perceptions (Tversky and Kahneman 1992). Kahneman and Tversky (1979) integrate the first three effects concerning the perception of a single outcome O_i in the so-called value function $V(O_i)$, where $\bar{O}$ represents the reference point, α the risk attitude, and β the loss aversion.

$$V(O_i) = \begin{cases} (O_i - \bar{O})^{\alpha} & \text{for } O_i \geq \bar{O} \\ -\beta(\bar{O} - O_i)^{\alpha} & \text{for } O_i < \bar{O} \end{cases} \quad (1)$$

The value function per se does not reflect the described risk attitudes and loss aversion, but a specific parametrization of the function is required. To implement loss aversion, β has to be strictly greater than one, and to implement the described risk attitude α has to lie within the range between one and zero. Figure 1 schematically illustrates the value function for such a parameterization. The difference in the valuation of losses and gains becomes obvious at the origin of the function, which is the reference point. Negative (losses) and positive (gains) deviations from that reference point are evaluated using different mathematical functions. The function for the loss part is steeper than that for the gain part. The different slopes reflect the concept of loss aversion. Additionally, the curvatures of the functions are different. The convexity of the left-hand side indicates the risk-seeking loss valuation, whereas the concavity of right-hand side implies the risk-averse gain valuation.

Viewed in isolation, the value function already reveals key observations about human value perception. However, it is insufficient in completely describing this complex process. Decision behaviors, such as insurance contracts as an example of risk-averse loss perception and gambling as an example of risk-seeking gain valuation, contradict the

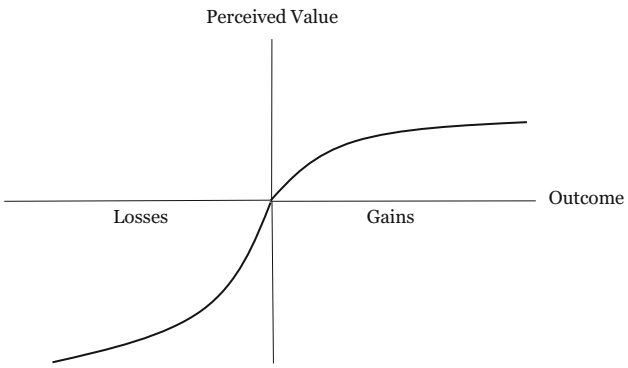

Fig. 1 Value function from PT

value functions. To overcome this shortcoming and to provide a closed model for human value perception, Kahneman and Tversky's (1979) theory, along with other descriptive theories for human decision-making, expands the idea of value perception from a narrow outcome-oriented perception to a combined perception of outcomes and probabilities. Through their concept of diminishing sensitivity, Tversky and Kahneman (1992) established the psychological foundation for the integration of probability perception. This concept states that human beings become less sensitive to changes in probabilities as they move away from their natural reference points of certainty (probability equal to 100 %) and impossibility (probability equal to 0 %). In other words, small probabilities are overvalued, while high and moderate probabilities are undervalued. The so-called weighting function from PT transfers objective probabilities p_i to perceived probabilities $w(p_i)$ by rescaling the objective probabilities consistent with the concept of diminishing sensitivity (Tversky and Kahneman 1992). The rescaling is achieved analytically via an inverse S-shaped weighting function that is first concave and then convex. Several empirical studies have validated this functional form (see, e.g., Gonzalez and Wu 1999).

$$w(p_i) = \frac{p_i^{\gamma}}{(p_i^{\gamma} + (1-p)^{\gamma})^{\frac{1}{\gamma}}} \tag{2}$$

Finally, PT combines the value function and the weighting function into a combined function for the perceived value PV, which is strongly aligned with EUT. This is especially appealing because PT can then be interpreted as "a special case of the widely accepted normative theory" (Gonzalez and Wu 1999, p. 158). The product of the weighted probability $w(p_i)$ and the outcome $v(O_i)$ equals the perceived value for that outcome. The sum of the perceived values for all possible outcomes represent the perceived value of the decision alternative. Thus, the perceived value of an alternative $PV(\tilde{O})$ resembles the functional form of an expected value:

$$PV(\tilde{O}) = \sum_{i=1}^{n} w(p_i)v(O_i) \tag{3}$$

The adjustment of the value function by the weighting function has important implications for the results on human value perception. The participation of people in lotteries is not compatible with a risk-averse gain valuation, as indicated in the value function. Following the definition of risk aversion, a risk-averse individual would never pay a participation fee that exceeds the expected value of the lottery winnings. However, if the small probability of winning a lottery is overvalued, the perceived value of playing the lottery can also exceed its expected value. Therefore, the overvaluation of small probabilities can override the undervaluation of the risky decision from the pure outcome perception and transform the risk-averse gain perception into a risk-seeking one. An equivalent example on the loss side is the conclusion of insurance contracts against large losses that occur with small probability. In this case, the risk-seeking loss perception that contradicts such a behavior is changed into a risk-averse perception by the overweighting of small probabilities. Combining both functions introduces the fourfold risk pattern (Tversky and Kahneman 1992). Losses underlie a risk-seeking perception for large and moderate probabilities and a risk-averse perception for small probabilities. Equivalently, the perception of gains is risk-averse for large and moderate probabilities and risk-seeking for small probabilities (Tversky and Kahneman 1992).

3 The Perceived Business Value of IT

In order to transfer the notion of individual value perception to the perceived value of IT within an organization, it is important to address three main issues. First, the perceived value of an outcome is not identical to the perceived value of an investment, as the value of an investment requires the consideration of the status quo and the time value of money. Second, the concept of perceived value has to be matched to the strategic dimensions of the objective BVIT to achieve a closed model that considers the unique aspects of IT investments. Third, the applicability of PT is generally restricted to individual decision-making rather than firm-level (group) decision-making. When managers make IT investment decisions, they may go through several rounds of meetings, discussions, and assessment. It is unclear whether PT is applicable to this kind of relatively rational group decision-making process.

Although PT focuses on one-period outcomes rather than on investment, the functional form of the perceived value is not restricted to one-period outcomes. In order to transfer the perceived value function from Eq. (3) to the context of IT investments $\tilde{I}$, we introduce different payment dates and the time value of money. Therefore, we replace an outcome O_i with an outcome for the net present value of the IT investment I_i. The net present value is defined as the difference between the discounted sum of the positive payments associated with the investment and the initial investment outflows. Ultimately, to derive the perceived value of an IT investment $PV(\tilde{I})$, we additionally need to consider the perceived value of the affected payments in the status quo $PV(\mathrm{SQ})$.

$$PV(\tilde{I}) = \sum_{i=1}^{n} w(p_i)v(I_i) - PV(\mathrm{SQ}) \tag{4}$$

To account for the two different value forms originating from IT investments, we match the dichotomy from the strategic dimensions of the objective value and the perceived value functions from PT. Therefore, we must determine whether IT investments are "framed" as a potential reduction of organizational losses or as a potential increase of organizational gains in the respective strategic dimensions. The concept of framing also originates from PT and states that variations in the formulation of a choice problem (i.e., in terms of gains or losses) provoke different value perceptions (Tversky and Kahneman 1981). If a problem is formulated in the gain context, it is accordingly evaluated from a risk-averse point of view for large and moderate probabilities and from a risk-seeking point of view for small probabilities. The risk attitudes, however, are reversed if the same problem is formulated in a loss context. The BVIT can originate from revenue investments and cost investments; typically, revenues are perceived positively, and costs are perceived negatively. Consequently, the hypothesis arises that revenue investments are framed in a gain context and cost investments in a loss context. This hypothesis has been confirmed by Fogelström et al. (2009) within the IT context of market-driven software product development. In a survey with 71 student participants from a software engineering master's program, they empirically demonstrate that software requirements associated with the revenue dimension underlie a risk-averse value perception, whereas software requirements associated with the cost dimension trigger a risk-seeking value perception. For our model, this means that the perception of revenues R can be described by the gain value function and that the perception of costs C follows the loss value function. In other words, the reference point for IT investments is zero. Therefore, the perceived values for cost and revenue investments can be described in the following form:

$$PV\left(\tilde{R}\right) = \sum_{i=1}^{n} w(p_i)(R_i)^{\alpha} - (\mathrm{SQ}_R)^{\alpha}$$

for revenue investments

$$PV\left(\tilde{C}\right) = \sum_{i=1}^{n} w(p_i)(-\beta(-C_i)^{\alpha}) + \beta(-\mathrm{SQ}_C)^{\alpha}$$

for cost investments

Finally, to transfer the concept of perceived value to the BVIT, we must consider that IT decisions are typically not individual; they are organizational. Indeed, the current literature shows no consensus about the question of whether PT can be applied for organizational decision-making. On the one hand, there is empirical evidence that PT can explain the risk–return decisions of organizations (e.g., Bromiley 1991; Fiegenbaum and Thomas 1988; Singh 1986). On the other hand, organizations also show behaviors that do not comply with original PT, such as the conservative behavior of organizations in the presence of poor performance (e.g., Chattopadhyay et al. 2001; Cameron et al. 1987). As is often the case, modern research results unite these opposing findings. The value function from PT can be applied to organizational valuation if the context of the organization is considered (Shimizu 2007) and if it is parameterized differently (Wen 2010). Whereas Kahneman and Tversky (1979) operationalize their value function with $\alpha = 0.88$ and $\beta = 2.25$, Wen (2010) derives a parameterization with $\alpha = 0.45$ and $\beta = 1.69$ for organizations. Thus, organizations underlie the same perception effects of asymmetric risk attitudes and loss aversion but on a more moderate level as compared to individuals. The applicability of the weighting function has, to the best of our knowledge, not yet been tested in an organizational context. However, the results from Wen (2010), which indicate an ambiguous rather than fourfold gain–loss perception, suggest that organizations do not follow the fourfold risk pattern and that they scale probabilities nearly correctly. Wen (2010) finds clear evidence for a risk-averse gain perception and a risk-seeking loss valuation. If organizations were subject to a fourfold risk pattern, it is likely that the clear results for the risk attitudes could not have been derived. Because there are indications that organizations scale probabilities correctly and there are no contradictory research results, we assume that organizations do not follow the fourfold risk pattern and that the weighting function is not descriptive for organizations. Consequently, the functions for perceived IT values are transformed to the following equations:

$$PV\left(\tilde{R}\right) = \sum_{i=1}^{n} p_i(R_i)^{\alpha} - (\mathrm{SQ}_R)^{\alpha}$$

for revenue investments

$$PV\left(\tilde{C}\right) = \sum_{i=1}^{n} p_i(-\beta(-C_i)^{\alpha}) + \beta(-\mathrm{SQ}_C)^{\alpha} \quad (6)$$

for cost investments

With the preceding argumentation, we introduced our model of the perceived value of IT, an approach that is new to this research stream and, thus, represents a new analytical lens for observing phenomena within this context. We illustrated that the different dimensions of strategic IT value can be assigned to different sections of the perceived value function from PT. This perceived value function incorporates four important features of human valuation perception: asymmetric risk aversion, loss aversion, reference point valuation, and nonlinear probability transformation. Although developed for individual value perception, the theory can be transferred to organizational

value perception, with the exception of probability scaling, by an adjustment of the parameterization. We conclude that organizations evaluate IT revenue investments as organizational gains and, thereby, differently than they evaluate IT cost investments. Whereas cost investments are perceived to reduce organizational losses and are accordingly evaluated from a risk-seeking perspective, revenue investments are considered to increase organizational gains and are evaluated from a risk-averse perspective. Moreover, cost investments are typically perceived to be more valuable as a result of the loss aversion. In the following, we apply our model to a concrete IT investment decision to analyze the productivity and perception paradoxes of IT. Therefore, we need to model the effects and the risks of an investment option. As both the isolated success of the IT project and the business environment can influence the effects of the investment, we consider multiple possible outcomes. The effects of an investment are then represented by the expected changes in the costs or revenues relative to the status quo μ. The risks of an investment are modeled as the variance of the relative effects σ^2.

In the Supplementary appendix (available online via http://link.springer.com), we show that the perceived BVIT from formula (6) can be approximated by the application of a two-step Taylor series for any probability distribution. This approximation describes the BVIT according to the first two moments of the underlying probability distribution: the expected effects and their variance. Additionally, the approximation makes revenue investments and cost investments mutually comparable, as their expressions are brought down to a similar functional form.

$$PV\left(\tilde{R}\right) \approx \alpha(\mathrm{SQ}_R)^{\alpha}\left(\mu_R + \frac{1}{2}(\alpha-1)\mu_R^2 + \frac{1}{2}(\alpha-1)\sigma_R^2\right)$$

for revenue investments

$$PV\left(\tilde{C}\right) \approx \beta\alpha(-\mathrm{SQ}_C)^{\alpha}\left(\mu_C - \frac{1}{2}(\alpha-1)\mu_C^2 - \frac{1}{2}(\alpha-1)\sigma_C^2\right)$$

for cost investments (7)

4 The Paradoxes of IT

4.1 The Perception Paradox of IT

BVIT research has shown that IT productivity is mainly associated with improvements in customer satisfaction, product and service quality, and convenience (i.e., effects are associated with revenue investments) (Papp 1999). Surprisingly, in practice this aspect of the BVIT is only partly perceived, and the cost-reduction effects of IT are more highly valued (Gartner 2013; Papp 1999; Henderson and Venkatraman 1993). This misperception is due to a variety of reasons. First, the revenue effects of IT are often intangible and, therefore, more difficult to quantify than the effects on costs are, demotivating managers from making revenue investments in IT (Papp 1999). Second, IT revenue investments typically face a higher risk than operational investments do because of the uncertainty of the competitive environment. IT can only create revenues via the interplay with market and environmental factors. Given the underlying dynamics of these factors, the risk of revenue investments is typically higher. Third, the information asymmetry between the users of IT and the senior managers of the organization supports such a biased cost focus. A disparity exists between the successes perceived by the two stakeholder groups ex-post to the investments. Whereas users experience the positive aspects of technology investments (e.g., service quality), senior managers do not realize these intangible effects; rather, they note only the high IT expenditures. As a result, senior managers become frustrated with IT, are not aware of the technology as a strategic asset, and view cost reduction as the main objective for IT decisions (Hirschheim and Lacity 2000).

All of these explanations take a perceptional perspective on IT decisions. Because the revenue effects of IT decision are intangible, decision makers perceive them as more risky. The information asymmetry and the associated frustration at the top-management level directly provoke such a one-sided perception. As PT is an acknowledged approach to quantify the value perceptions of human beings and organizations (Wen 2010), it may provide additional insights and explanations for this perceptional issue. The behavioral element's loss aversion and asymmetric risk attitudes may further confirm the existence of this paradox. PT formulates that loss reduction is more valuable than an equal amount of gain increase. If the risks of gain increases and loss reductions are also considered, the asymmetric risk attitudes reinforce the perceptional dominance of loss reductions. In other words, the risk diminishes the perceived value of gain increases, but amplifies the perceived value of loss reductions. Because cost investments are framed as loss reductions and revenue investments as gain increases, cost investments inherit the perceptional dominance of loss reductions.

Based on our model, we can prove this claim analytically. To that end, we compare the perceived values for two identical IT investments that differ only in their type. In doing so, we distinguish the perceptional effects described by PT from the other explanations, such as the different risk–return profiles. This controlled setting enables us to show that the perception paradox still holds if the other explanations are not given, and that the irrational value perception is responsible for the perception paradox. Even if this constructed decision between two identical investments is unrealistic, the proof under the artificial conditions suggests that the true explanation for the paradox does not

lie exclusively in one of the presented approaches but in a combination of them. The application of PT, therefore, complements and enhances the existing theory in this regard.

The mathematical proof is depicted in the Supplementary appendix. The proof implies that the perception paradox holds true for identical IT investments with positive expected effects. If the information provided about the investments suggests positive performance effects, loss aversion and asymmetric risk attitudes can explain a biased choice between cost and revenue investments. This condition is probably fulfilled in reality. In general, high-level executives make IT decisions based on proposals from the IT department; moreover, the IT department is unlikely to propose investment opportunities with negative business cases to the senior executives (Tallon et al. 2001). Ultimately, the analysis reveals that the perception paradox has a negative influence on the BVIT, as it implies that more valuable revenue investments with higher expected effects are eschewed in favor of objectively less valuable cost investments.

4.2 The Productivity Paradox of IT

The possible explanations for the productivity paradox can be classified into four categories. First, unique characteristics of IT capital investments, such as the high pace of technological improvements, require organizations to replace or upgrade their IT more frequently than they do other capital investments. With every adjustment of the IT landscape, an organization loses experience effects, and productivity decreases (Yorukoglu 1998; David 1991). Consequently, the overall productivity effects of IT investments are smaller than those for traditional investments. Second, measurement errors in pioneer studies on the value of IT may be responsible for the emergence of the productivity paradox. These measurement errors stem from the general weaknesses of productivity statistics, which become especially relevant within the context of IT productivity (Denison 1989). Productivity statistics typically underestimate quality and speed improvements, which are exactly the main benefits of IT investments (Brynjolfsson 1993). Third, the value of IT could be of a redistributive rather than a creative nature. In other words, IT may be valuable to certain organizations but unproductive when considering several competing organizations. This is because the value of IT can be grounded in the exclusivity of information, enabling an organization to attract market shares from competitors (Brynjolfsson 1993). Fourth, and probably most obviously, the productivity paradox exists because of poor investment decisions or failures in the management of IT projects. Indeed, empirical results illustrate that the success of an IT project depends highly on correct management and valuation procedures (Petter et al. 2013).

With the consideration of the measurement errors and the application of more sophisticated methods, a significant number of studies have shown the existence of the BVIT (e.g., Tallon et al. 2001; Gurbaxani et al. 1998). However, the valuation issue of IT is still valid today and is often referred to as the "new productivity paradox." The new productivity paradox was coined by Anderson et al. (2003) and postulates that although IT returns do exist, the estimates for these returns tend to be overestimated (Dewan et al. 2007). One explanation for the new productivity paradox is hidden IT capital. Brynjolfsson and Hitt (1995) argue that IT investments are always carried out in a decentralized fashion, which makes it hard to estimate and track the complete extent of invested capital. Underestimating the invested capital leads automatically to an overestimation of IT returns. Another explanation for the new productivity paradox lies in complementary organizational investments that typically follow IT investments. Unlike traditional capital investments, IT investments require organizational changes to create the expected return. These additional investments in the organizational capital are often not considered in IT return estimates.

By analyzing the new productivity paradox within our model, we can provide an alternative, or complementary, explanation for the observation. Although the true explanation is likely to be a mixture of the presented notions, every additional part of the puzzle enables the entire theory to better explain reality. Having shown the preference for IT cost investments, we also focus the analysis of the new productivity paradox on this investment type. Readdressing the derived perceived value of cost investments, it becomes evident that the variance and, therefore, the risk of such investments are perceived positively. This is because of the risk-seeking valuation of organizational losses. The reasoning can be illustrated mathematically by showing that the first derivative of the perceived value function with respect to the variance is strictly positive (see Supplementary appendix).

As a consequence of the positive valuation of risk $(\alpha < 1)$, the BVIT is overestimated relative to the expected effects. In other words, the perceived value of IT is larger than the expected value of IT. If a failure is defined as a negative deviation from the target value, assigning a higher value to these investments naturally leads to a higher failure rate.

4.3 Resolutions for the Paradoxes

At the same time our model provides new insights into the origins of the paradoxes, it also derives two possible resolutions for them. First, a shift in the corporate culture

concerning the reputation of IT within an organization can help to overcome the irrationalities in the decision process. We demonstrate that loss aversion and asymmetric risk attitudes are at least partly responsible for the perception and productivity paradoxes. A possible solution for the paradoxes can be a change within the mindset of practical decision makers. If IT is no longer understood as a cost factor but as a source of competitive advantage and transformability, basic issues of the paradoxes can be resolved. Within our model, this shift in perspectives results in an adjustment of the reference point from a pure gain–loss perspective (reference point equals zero) to a status quo consideration. In terms of PT, the framing of the different investment types is eliminated. Consequently, a reduction of costs and an increase in revenues are both perceived as an increase in profits. As a result, cost and revenue investments are perceived equally, and at least one foundation of the perception paradox can no longer exist. Moreover, the productivity paradox is also solved with such a switch in perspectives; the overvaluation of IT cost investments is replaced by undervaluation. Similar to risk-dependent overvaluation, undervaluation becomes more extreme for riskier investments. A higher risk results in the realization of more extreme effects, both in the positive and negative directions. The loss aversion causes decision makers to perceive the more positive effects as less valuable relative to their negative perception of the more extreme downsides. From an economic point of view, undervaluation is probably less problematic than overvaluation, as the only investment opportunities executed are those still profitable after a risk discount. Consequently, rather than the false decision-making described in the productivity paradox, decision quality increases due to more prudent value perception. This argumentation only holds if an organization has sufficient investment opportunities. If this is not the case, the organization misses favorable investment opportunities and, thereby, again reduces the value of their IT. However, in a realistic setting, the IT budget is probably smaller than the firm's investment opportunities.

A second possible resolution for these incidents of perception biases and, therefore, for the paradoxes is the establishment of financial constraints and corporate governance mechanisms. Wen (2010) empirically demonstrates that the ambiguity and irrationalities in organizational decision-making can be prevented if such control strategies are executed, although the individual decision makers still underlie these issues. The enhancement of corporate governance mechanisms, "high cash flow rights of controlling groups, high percentage of board seats held by non-controlling groups, high ownership of board members and independent director" are adequate actions to overcome the problems associated with irrational decision-making (Wen 2010, p. 126).

5 Discussion and Conclusion

BVIT research analyzes the performance effects of IT at the firm level. This research stream originates from historic doubts regarding the productivity impacts of IT investments. For the last 30 years, BVIT researchers have focused on alleviating these doubts and on analyzing the basic conditions and attributes of IT value. In addition to empirical and analytical approaches, the conceptual research stream applies economic theories to construct the scientific underpinning for the value proposition of IT. We take up this approach and develop the concept of the perceived BVIT. The perceived BVIT is defined as the decision maker's mental interpretation of potential IT performance effects. Both concepts are different constructions of the same object and are, thus, related to each other. The perceived BVIT determines the IT investment opportunities chosen in the decision process and, ultimately, the structure of the IT landscape. In this way, it serves as a kind of filter for IT investments. Only IT investments with a high perceived BVIT are executed and create BVIT for organizations; opportunities with a BVIT perceived as low are not implemented and, thus, not associated with the BVIT. The key problem of IT value perception is that it is prone to the biases of loss aversion, of reference point-dependent valuation, and of asymmetric risk attitudes. To quantify and investigate the effects of these biases on IT decision-making, we set up a model for BVIT perception by applying PT. Based on our model, we ultimately show that the classical biases, inherent in human value perception, lead to irrational perception schemata, such as the preference of cost investments over revenue investments (perception paradox) and the structural overvaluation of IT benefits (productivity paradox). The perception paradox biases the investment decision toward cost investments; objectively more valuable revenue investments may be neglected in favor of objectively less valuable cost investments. The misperceptions associated with the productivity paradox lead to a high proportion of IT investments that cannot meet expectations and, thus, to a riskier investment strategy. Overall, we can state that the biased perception makes the selection of IT investment irrational. Therefore, in reality, the realized BVIT is lower than it could be. Figure 2 illustrates our framework and our research results.

A better understanding of the irrationalities influencing IT decisions can provide the basis for the derivation of potential solutions and retaliatory actions. A possible approach is an adjustment of the corporate culture. If IT is perceived as a value driver, and not as a cost factor, of organizations, the value paradoxes are corrected automatically. The basic mechanisms of PT still hold, but the elimination of the framing effects resolve the ambiguous

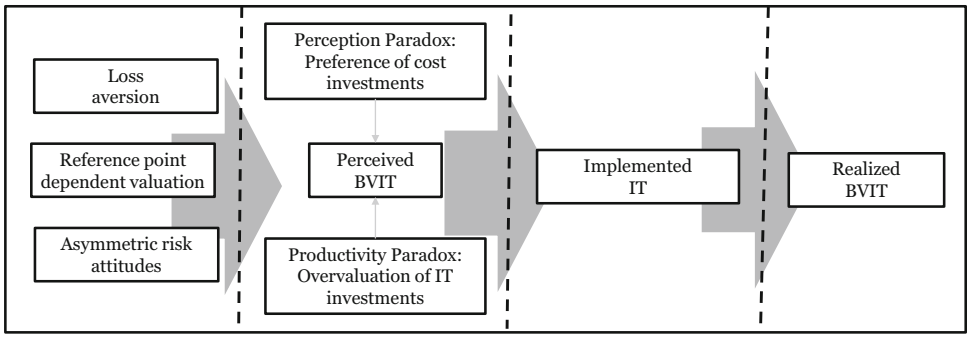

Fig. 2 The perceived value of IT

value perception. A second approach for the avoidance of an irrational selection of IT projects is the establishment of adequate corporate governance mechanisms and financial constraints. This is because both strategies avoid loss aversion and asymmetric risk attitudes in organizational decision-making and, therefore, resolve the ambiguous perception at its origin.

The scientific contribution of this paper is twofold. First, we apply one of the most honored economic theories to the context of BVIT research and quantify the perceived BVIT. In doing so, we expand the toolkit for future analyses and studies in this discipline. Second, we theoretically prove that irrationalities in human valuation behavior are (at least partly) responsible for the existence of two fundamental paradoxes of IT. For this reason, we want to encourage a rethinking within the practical perception of IT. We analytically show that the value of IT would be higher and perceived more accurately if decision makers avoid unfairly viewing IT departments as cost factor. This result is somewhat philosophical and can be criticized as suffering from a certain tautology. Indeed, the notion that IT creates value if this value is also perceived, can be described as a self-fulfilling prophecy. However, the loss aversion and asymmetric risk assessment observed in human behavior explicitly require this kind of rethinking.

Although PT has already been applied in IS research for the explanation of certain phenomena, such as the escalation of IT projects and the bidding behavior in software projects, it has not yet been established as a general theoretical approach for BVIT research (Fleischmann et al. 2014). The reason for this may be that the conceptual and quantitative research streams typically focus on the performance effects of the existing IT landscape in their organizational environment and, frequently, do not consider the existing IT as stemming from prior decision problems. Thereby, the ex post BVIT is their main research object. In contrast, the analytical research stream focuses foremost on the ex ante BVIT and develops decision models that determine the optimal selection of IT projects. We adopt this point of view of an ex ante decision problem, but we descriptively analyze how the decision problem might be approached in practice. In doing so, we adopt the predominant perspective of the analytical research stream to focus on the main research objective of the empirical and conceptual approaches. As a result, this study investigates not only the characteristics of IT in its role in the value creation of an organization but also its attributes within the decision process. Features such as the risk–return profile, the type of IT investment, and the corporate governance and culture should be integrated in further analyses of the BVIT.

Thus, our approach complements the existing conceptual underpinning for BVIT research, as it introduces a new perspective on the issue. The same holds true for the explanation of both of the paradoxes. The application of PT reinforces the extant research results from another perspective and provides additional insights regarding the resolution of the paradoxes. Therefore, the theoretical contribution of our paper to BVIT research and the two paradoxes does not lie in a radical reorganization of the conceptual background, but in the expansion of it. With every complementary contribution, it is critical to question whether the presumably higher explanatory power of the theory justifies the higher degree of complexity. As is often the case in economic research, the answer to this question is: it depends. More specifically, it depends on the validity of the research results. If the additional consideration of PT enhances the explanatory power of the entire theoretical framework of BVIT research, the higher complexity is justified. As PT focuses on different aspects than the existing theoretical concepts do, the explanatory power of the entire framework is likely to increase. However, the final answer to the validity question can only be found through quantitative and empirical analyses. Based on our findings, we can derive two central hypotheses for such an empirical validation. First, the higher the firm's degree of loss aversion and asymmetry of risk attitudes is, the larger is the portion of its IT investment portfolio focused on the reduction of operational costs. We have theoretically shown that more pronounced biases lead to a less balanced perception of cost and revenue investments and, consequently, to a less balanced IT landscape. Second, the higher

the firm's degree of loss aversion and asymmetry of risk attitudes is, the higher is the perceived failure rate of the firm's IT investments. Our model suggests that more pronounced biases lead to a higher overestimation of IT benefits, which, in turn, more easily provokes frustration with the investments. The appropriate methodology for the validation of these hypotheses is probably an empirical field study. The loss aversion and the asymmetry of risk attitudes of the firm's decision makers can be applied as independent variables. Additionally, variables that describe the corporate governance of the firm can be used, as Wen (2010) reveals a positive relationship between the pronunciations of the biases and the corporate governance. As for the dependent variables, the ratio between cost and revenue investments is promising for the first hypothesis, and the perceived failure rate of the decision makers is applicable for the second one. Significantly positive and substantial relationships between the independent and dependent variables would support our findings. The required data has to be gathered from questioning the firm's decision makers and from archival sources. Overall, we believe that the perceptional perspective on the BVIT is a promising field for future research and that our model constitutes a solid foundation for that purpose.

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