Ontology of Value, Risk and Cognitive Biases for an IT Portfolio Decision Making

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Abstract. *Decisions about whether or not to kill an ongoing project of an IT portfolio may be critical. A bad decision to continue with a project with a high probability of making things worse, in exchange of a small chance of avoiding a large loss, often turns manageable failures into disasters. However, these decisions can be negatively impacted by cognitive biases of decision makers, such as the loss aversion, which are enhanced when uncertainty is substantial and information incomplete. As a result, it is important to reduce the biases in these decisions. This paper introduces an ongoing research that aims to create an ontology to improve the understanding of these cognitive biases. It can be used as part of a strategy to reduce biases in a risk and value analysis.*

1. Introduction

Decisions over the project portfolio are often referred to as the point where strategy is put into action and is therefore crucial for the companies in order to reach their strategic goals. This is achieved through the successful selection and execution of an appropriate mix of projects, through a process known as project portfolio management (PPM). As the dependency on information technology (IT) for organizational performance increases, organizations must use IT portfolio management techniques to ensure that the IT projects are aligned with the organizational strategic objectives. Making a portfolio decision is far from trivial. This decision process is characterized by uncertain and changing information, dynamic opportunities, multiple goals and strategic considerations and interdependence among projects (LEVINE, 2007, p.319).

In this research proposal, we focus on making Go/Kill decisions on individual IT projects on an ongoing basis (LEVINE, 2007, p.319), in other words, deciding to keep or to remove an ongoing project from the IT portfolio. A bad decision to continue with a project with a high probability of making things worse, in exchange of a small possibility of avoiding a large loss, often turns manageable failures into disasters (KAHNEMAN, 2011).

These decisions can be negatively impacted by cognitive biases (KAHNEMAN, 2011). Cognitive biases are systematic errors that recur predictably in particular circumstances, such as decision making under uncertainty (KAHNEMAN, 2011). In

this research, we consider the loss aversion, risk seeking and framing effects cognitive biases and will be detailed in section 2.

Therefore, to improve the decision making, it is important to better understand how these biases occur, how to deal with them, and how to help to reduce their negative consequences. In this sense, a considerable number of studies have been done in strategic decision making (e.g. KAHNEMAN et al., 2011; KAHNEMAN, 2011; CRISTOFARO, 2017; ABATECOLA et al., 2018). However, despite the relevance of IT PPM to organizations, there is a lack of empirical studies relating portfolio management to cognitive biases, specifically in the software projects context (DA CUNHA & DE MOURA, 2015). Besides, there are still fewer studies about removing or reducing cognitive biases in IT portfolio management (e.g. IDLER & SPANG, 2019; PEDERSEN, 2016). Therefore, our research question is:

How can we (de-bias) mitigate or reduce the negative consequences of the cognitive biases (loss aversion, risk seeking and framing effects) in the Go/Kill decisions of ongoing individual projects in an IT portfolio?

This paper is structured as follows. Section 2 presents behavioral economics. Section 2.1 details the heuristics and biases and how it occurs; Section 2.2 shows the cumulative prospect theory and how it is used to predict the decision making. Section 3 defines IT portfolio concepts. Section 4 presents one ontology of value and risk. Section 5 presents the design science research as the research method used in our research proposal, and section 6, our proposed ontology.

2. Behavioral Economics

Behavioral economics (BE) is a descriptive theory that focuses on how decisions are actually made while a normative decision theory is about how decisions should be made in order to be rational. One of the main foundations of BE is the dual process theory. It aims to explain the decision-making process from the view of decision makers through a general framework comprising two distinct systems of thinking: System 1 and System 2. System 2 corresponds to reasoned thinking, that has effortful mental activities; System 1 corresponds to intuitive thinking and operates automatically and quickly, with little or no effort, and no sense of voluntary control (KAHNEMAN, 2011). BE research aims to understand how the intuitive and the reasoned thinking fail and how they are effective (KAHNEMAN, 2011).

2.1. Heuristics and Biases

To reduce difficult mental tasks, such as assessing probabilities and predicting values, decision makers often use heuristics. These procedures include computational shortcuts and editing operations, such as eliminating common components and discarding nonessential differences for arriving at satisfactory solutions with modest amounts of computation (KAHNEMAN, 2011). While these broadly accurate heuristics work most of the time and can generally be described as very powerful (GIGERENZER, 1999), they are also the source of systematic errors, known as psychological biases or cognitive biases, and that recur predictably in particular circumstances, such as decision making under uncertainty (KAHNEMAN, 2011).

Therefore, value and risk analyses are subject to several cognitive biases, because they are human-centric activities that require estimating likelihood of

occurrence and potential impact, under uncertainty (NOYES et al., 2012). The significant role cognitive biases play in risk management has been acknowledged by both ISO31000:2018 and COSO:ERM 2017, that are important risk management guidelines (SIDORENKO, 2018).

In this research proposal, we use the cognitive bias typology of Arnott (2006, Table 1) that was proposed to support the development of decision support systems (DSS). The specific cognitive biases studied in our research are loss aversion, risk seeking and framing effects. Framing effects (KAHNEMAN, 2011) occur when events framed as either losses or gains may be evaluated differently. Perceptions of risk can be affected by the way in which a situation is presented and they are particularly vulnerable to framing effects, which influence the way individuals approach a risk, and have biases in the decisions they make (NOYES et al., 2012). Loss aversion is one of the basic phenomena of choice under both risk and uncertainty in which losses loom larger than gains (KAHNEMAN, 2011). Loss aversion has been used to explain other biases, such as the endowment effect and sunk cost fallacy (KAHNEMAN, 2011). Finally, risk seeking integrates one of the core achievements of cumulative prospect theory (CPT) that is the fourfold pattern of risk attitudes. This pattern is presented in the next section, that introduces the CPT. CPT allows a better understanding of the cognitive biases.

2.2. Cumulative Prospect Theory (CPT)

CPT is a descriptive theory and extends prospect theory to uncertain as well as to risky prospects with any number of outcomes while preserving most of its essential features (KAHNEMAN, 2011). It is based on the dual process theory.

Three cognitive features, all operating characteristics of System 1 (intuitive thinking), are the foundation of cumulative prospect theory (Kahneman, 2011, p. 281-2). They are: (1) evaluation is relative to a neutral reference point and this point defines what is a gain and what is a loss; (2) there is diminishing sensitivity to both increasing values and increasing gains or losses; and (3) losses loom larger than gains in decision maker's minds (ARNOTT and GAO 2019).

One of the core achievements of CPT is the fourfold pattern of risk attitudes: risk aversion for gains and risk seeking for losses of medium and high probability; risk seeking for gains and risk aversion for losses of low probability (KAHNEMAN, 2011).

3. IT Project Portfolio Management

Project portfolio management (PPM) consists of two different parts or phases: (1) project portfolio selection and (2) portfolio management. The first phase is to select projects for the pipeline. This phase includes a structured process to deal with project proposals and how they can be evaluated. The second phase is to maintain the project pipeline. Once the selected projects are being executed, they need to be monitored and evaluated to ensure that they still fulfil the conditions of the original selection criteria. If the conditions change it needs to be reconsidered if the project should remain in the portfolio or be terminated (LEVINE, 2005). Our focus in this research proposal is on this last decision that is called Go/Kill decision.

In the information technology (IT) context, IT portfolio management provides the discipline of balancing risk against expected returns, evaluating the performance and utilization of existing systems, analyzing and assessing alternatives and trade-offs, and

removing waste resulting in significant efficiencies and cost savings. To be able to make this complex decision, experienced IT-projects portfolio managers use many methods to quantify risks, costs, value, and performance of the IT projects (MAIZLISH and HANDLER, 2005, p.66), and combine deliberate rational analysis (reasoned thinking) with experienced-based intuition (intuitive thinking) (PEDERSEN, 2016). Therefore, risk and value analyses are important activities for the Go/Kill decision in IT PPM.

4. Ontology of Value and Risk

Sales et al. (2018) have presented an ontological analysis of risk which makes explicit the deep connections between the concepts of value and risk. They have also proposed a concrete artifact, namely the Common Ontology of Value and Risk, formalized in OntoUML. They formally characterized the process of ascribing risk as a particular case of the process of ascribing value (in the sense of *use value*).

This ontology considers three perspectives: (1) an *experiential perspective*; (2) a *relational perspective*; and (3) a *quantitative perspective*, which projects value and risk on measurable scales and it is our focus in this research proposal.

Risk and value have the following similarities: (a) goal dependency; (b) context dependency; (c) uncertainty and impact in the conceptualization of both: the computation of the likelihood of an event times its impact on one's objectives and preferences fits the quantitative analysis of both risk and value. The impact for the value is related to achieving goals. This opens the possibility of applying methodologies and techniques developed for value analysis in marketing and economics to the case of risk analysis, and vice versa. Risk analysis is traditionally accepted as a complex and critical activity in various contexts, such as strategic and project planning, finance, engineering of complex systems, and software development (SALES et al., 2018).

5. Research Method

We selected design science research (DSR) as the research method, because of its strength in solving a real problem using applied research (PEFFERS et al. 2007) in the field of information systems; in our case, an ontology to help analysts identify the existence of some potential biases in a risk and value analysis of a Go/Kill decision in an IT portfolio.

We will evaluate the ontology by focus group analysis. These groups are formed by IT portfolio decision makers and DSS analysts. We will use the pragmatic perspective to evaluate the perception of utility of the ontology in a de-biasing strategy.

6. Solution Proposal

De-biasing requires the decision support systems (DSS) analyst to understand the mechanisms underlying the particular bias that is subject of change. Each bias can have a different de-biasing approach, and this makes de-biasing difficult in practice as it requires significant effort from the analyst (ARNOTT and GAO 2019).

To answer the research question, we propose an ontology representing the Go/Kill decisions associated to IT projects and their values, risks and cognitive biases. The proposed ontology extends the Common Ontology of Value and Risk (SALLES et al., 2018) because value and risk analyses are at the core of the Go/Kill decisions and it

uses cumulative prospect theory (CPT) as the decision making theory under uncertainty to support the value and risk analysis. We use CPT because it may allow a better understanding of the cognitive biases considered in our research problem.

Furthermore, the true semantics of what is *value* and how the cognitive biases sometimes negatively affect decision making are sometimes not well understood. Its semantic essence can be better explored and represented to identify other potential associated elements. In the literature review, we found just one ontology (LORTAL et al., 2014) used to reduce cognitive biases. The aim of this ontology was to quantify the risk of occurrence of a cognitive bias in the intelligence domain. This ontology can model the probability and severity parameters for risk assessment. Moreover, although there are a few proposals of ontologies (KORNYSHOVA and DENECKERE, 2010; NOWARA, 2017) that deal with intuitive decision making, which are the source of cognitive biases, they do not consider the cognitive biases. So, to the best of our knowledge, there are no ontologies considering the loss aversion, risk seeking and framing effects cognitive biases for a decision making under uncertainty.

In particular, we plan to extend the ontology of Salles et al. (2018) by, initially, (i) including the concepts of decision making according to CPT to measure value and risks relative to a reference point (rather than absolute outcomes), according to the pattern of risk attitudes; (ii) taking into account cognitive biases related to value and risk; and (iii) adapting the concepts of risk assessment of a cognitive bias from the ontology of Lortal et al. (2014) to loss aversion, risk seeking and framing effects for IT portfolio Go/Kill decisions. Most decision makers are unaware that they use reference points, so they are likely to decide without realizing how it can bias their choice of action (FRENCH et al, 2009, p. 38).

Our proposed ontology aims to improve the understanding by the analysts of these decision biases and the situation in which they occur. This ontology can be used as part of a strategy to reduce the biases in the Go/Kill decisions of an IT portfolio. More specifically, our focus is on developing DSS as a de-bias strategy (LARRICK, 2004). We use the debiasing process of Arnott (2006) because it was developed to support DSS development projects. Our focus is on the first step of this process: to identify the existence and nature of the potential bias. As value and risk are very important to the goal achievements of an IT portfolio and as their measurements may be subject to cognitive biases, thus it is of fundamental importance that these elements and their relations be well understood to support the first step of this debiasing process. So, we argue that one ontology representing the Go/Kill decision of a project in an IT portfolio with its values, risks and possible biases considered in our research can help DSS analysts identifying the existence of these biases.

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