

**A Systematic Review of Decision Making under Uncertainty – An
Integrative Framework Approach.**

Sterling Rauseo and Hong T. M. Bui

Southampton Business School, University of Southampton, Southampton SO17, 1BJ UK.

Email: s.rauseo@soton.ac.uk; hong.bui@soton.ac.uk

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ABSTRACT

Decision making under high uncertainty has attracted intense interest given the turbulent economic and political world environment. Undertaking a systematic review of decision making under uncertainty from 135 primary studies (refined from an initial search of 1814 papers) dedicated to this topic covering the period 2000-2015, we developed an integrated framework showing the relationship between the decision making process and strategies under uncertainty. The findings also highlight the dimensions of uncertainty and context that affect decision making. It is believed that this study will shape future research in impact of decision making within the contexts of individual and group dynamics, education, individual competency, or macro-settings on the execution of decision making under uncertainty.

Keywords:

decision making; uncertainty; strategy

Word count: 7,386

INTRODUCTION

“Uncertainty is the very condition to impel man to unfold his powers.” (Fromm, 1986, p.45).

Uncertainty has been extensively explored in the past century in decision making (Hastie, 2001; Lipshitz & Strauss, 1997; Simon, 1979; Tversky & Kahneman, 1974), management and economics (Alchian, 1950; Bourgeois, 1985; Courtney et al., 1997; Duncan, 1972; Knight, 1921; Milliken, 1987). Furthermore, uncertainty has been defined as the inability to determined probabilities of outcomes (Knight, 1921), classified, as state, effect and response (Milliken, 1987), and its influence on the trade-off of timing in competitive strategy (Wernerfelt and Karnani, 1987) has been noted. In exploring uncertainty in the context of the organization the focus is the development and implementation of strategy (Mueller et al., 2013; Wernerfelt & Karani, 1987; Wiltbank et al., 2006) and the impact of the TMT in the decision making process (Aharoni et al., 2011; Auh & Menguc, 2005; Cannella, Park & Lee, 2008) when considering the firm’s resources, capabilities and competencies in addressing the sources of uncertainties (Dowell & Killaly, 2009; Hillman et al., 2009).

The manifestation of decision making under uncertainty has been seen in the breadth of innovative research that has been undertaken to date (Leiponen and Helfat, 2010; van Riel et al., 2004). It has also been seen in the field of entrepreneurship in the influence of entrepreneurial perceptions to formulate corporate entrepreneurial strategy (Neill and York, 2012); in differences in how middle and senior managers decide on pursuing innovation (Behrens *et al.*, 2014); in the search for knowledge, and in how social networks can be important (Leyden *et al.*, 2014). These two areas of innovation and entrepreneurship are good surrogates to look at decision making under uncertainty as globalization has increased the pressure for firms to innovate in order to stay competitive over time (Mueller *et al.*, 2013). In addition, understanding decision making in an international environment has not been given

sufficient attention even though it is crucial to the success of an organisation (Aharoni *et al.*, 2011).

The questions that then arises are 1) how is strategic decision making process of firms different when there is an environment of uncertainty; and 2) what is the implication of this difference in how it employs its competencies, capabilities and resources in its eventual strategy. While quantitative approaches to decision making under uncertainty as part of forecasting including statistical techniques and modelling has been helpful and widely used, they leave an important gap as to the need for human judgement as part of the decision making process especially in highly uncertain or complex situations (Goodwin *et al.*, 2011). In addition, there is an increasing realisation that accepted and widely used decision making modelling has to take into account behavioural aspects if it is to be beneficial to organisational change and performance (Luoma, 2016).

It is to answer these questions and address these gaps we conduct a critical review of strategic decision making process under uncertainty which includes enlisting the cognate fields of innovation and entrepreneurship. The result of the review process is a the development of an extended theoretical framework model that highlights some key relationships among the strategic decision making process, competencies, capabilities, resources and the strategies that result when operating in an environment of uncertainty. The purpose of the study is to conduct a systematic review of decision making, and uncertainty to synthesize research from these broad and interconnected areas to develop a framework model that explains the relationships and their interactions. We hope that this framework will facilitate a greater exchange of learning and exchange across a diverse field and produce “accretive intellectual progress” (Lee at al., 2014, p.340).

Our main contributions are two-fold. First, we provide an outline of the multidimensional elements to strategic decision making under uncertainty. Second, we

develop a holistic framework to explain the sources and interrelationships among variables. The existing research seems to be fragmented with a siloed approach, and existing models and theories tend to be too narrow and simplified despite the fact that they are shown to be much more complex in reality (Nielsen & Nielsen, 2013).

THEORETICAL FOUNDATION

The theoretical foundations in the area of decision making from the papers reviewed drew predominantly on resource-based view (RBV) (Lado and Wilson, 1994), strategic foresight (Rohrbeck and Germüden, 2011), real options (Wu and Ong, 2008), contingency theory (Gans and Stern, 2003), and uncertainty (Knight, 1921) to name a few. In addition, organizational concepts and interventions like competencies and capabilities (Fredrick, 2005), cognition (Kaplan, 2008), perceptions (Kor *et al.*, 2007), and TMT (Heavey and Simsek, 2013) are significant in decision making under high uncertainty dynamics. Drawing on the vast literature we classified the key theoretical foundations of decision making under the themes of *psychology, cognitive and social context; competencies, capabilities and resources; and organization and uncertainty*. These themes represented the central basis of how these theories have been utilized to understand and explain decision making under uncertainty.

Psychology, Cognitive and Social

The complexity of decision making under uncertainty has attracted diverse theoretical explanations over the decades as the nature and prevalence of its occurrences have evolved and increased. In looking at individual cognition and psychology, the predominant theoretical framework, historically, has been sensemaking and behavioural decision theories. Cognition and sensemaking theories have been shown to be important in capability needs and development in disruptive change (Kaplan *et al.*, 2003), judgment under uncertainty (Tversky

and Kahneman, 1974); the strategic decision management process (SDMP) (Haleblian and Rajagopalan, 2006) at different levels of the organization (Walsh, 1995); framing contests in organizational strategy making in a turbulent environment (Kaplan, 2008); entrepreneurial action (McKelvie *et al.*, 2011); and scenario planning in strategic decision situations (Meissner and Wulf, 2013).

Behavioural decision making theory (BDT) moves the focus away from a purely normative rational choice towards an understanding of the non-rational ways humans make decisions particularly during times of high uncertainty, as with “unknown unknowns” or black swans (Feduzi and Runde, 2014). Counteracting the adverse effects of managerial cognitive bias as shown with BDT and framing bias from prospect theory (Shimizu, 2007) is a predominant aim in management, and, in particular, scenario planning employs this effectively in the strategic foresight activities of firms (Meissner and Wulf, 2013). The cognitive perspective has been employed to explore how entrepreneurial opportunities arise or are created rather than how they are discovered (Alvarez and Barney, 2007; Cornelissen and Clarke, 2010; Gregoire *et al.*, 2011). Grounded in how individuals’ beliefs and attitudes are influenced by external factors and how this guides their course of action, the theory of reasoned action has been adopted as an explanation for managerial scanning behaviours for competitive intelligence in entrepreneurial endeavours (Qiu, 2008) and the perceived effectiveness of managerial influence strategies in an international setting (Fu *et al.*, 2004).

The behavioural theory of a firm depicts the organization as a collection of individuals and how this collective phenomenon impacts upon strategic decision making and risk taking in areas such as international entry mode (Ji and Dimitratos, 2013). It can also be seen in government regulation and investment decision making (with RBV) (Hoffmann *et al.*, 2009). It is visible in emerging industries, products and services in explaining the competing dilemma

of isomorphism advocated by institutional theory to reduce mortality and superstitious learning from organizational theory which increases the mortality hazard (Miller, 2012).

Competencies, Capabilities and Resources

The resource based view (RBV) theory emphasizes how a firm maintains its competitive advantage by acquiring and deploying its human and non-human resources and capabilities. This theory has been popularly used as the go-to theoretical framework. At the individual level, RBV is often applied in the discussion on competencies and leadership to explain leveraging internal competencies in international market entry decisions (Akhter and Robles, 2006), and the impact of uncertainty in explaining entrepreneurial action (McKelvie *et al.*, 2011). Some discussions addressed human resource and leadership competencies, and practices in the uncertainty context like R&D cooperation (Stock *et al.*, 2014). At the firm level, RBV has been applied to explain capabilities development and cognition by defining dynamic capabilities that enhance innovation projects and managerial practices (Lee and Kelley, 2008). It has also been applied to explain strategic sourcing in the supply chain to keep firms flexible and agile (Chiang *et al.*, 2012).

The upper echelon theory reflecting the important role of top management in strategic decision making has also been significantly cited. Managerial discretion is seen as key in innovation and sale diversification through exports (Sahaym *et al.*, 2012). In addition, it is suggested that the CEO's influence is important to the top management team behaviour in driving firm performance under environmental uncertainty (Carmeli *et al.*, 2011).

Institutional theory reaches outside the individual and organizational level, and explains the impact the external environment and institutions have on the behaviour and actions of the firm (Meyer and Rowan, 1977; DiMaggio and Powell, 1991). This theory has also been combined with other theories to explain the impact of institutional norms, rules and

attitudes on the difference between entrepreneurial firms performance from mature firms (Autio *et al.*, 2011).

Trial and error learning or experimentation explains how, when faced with novel and uncertain situations, organisation can develop their solutions (Loch *et al.*, 2008). This theoretical foundation has been employed to account for how small investments in a start-up could address innovation deficiency and redress this deficiency, as well as filling the capabilities gaps in an existing firm (Keil *et al.*, 2008). Advocates of this theoretical foundation also postulate that it is employed within organizational processes and culture to encourage innovation willingness among employees (Lee *et al.*, 2004).

Organization

Apart from the above theories, there are a number of other theories that depict organizational decision making. For example, *transaction cost economics* (TCE) has been widely utilized to demonstrate firms' behaviour when choosing such things as the source of an international expansion and entry (Brouthers *et al.*, 2008), and outsourcing (van de Vrande *et al.*, 2009); while *contingency theory* has described how firms in transitional countries, like China - where entrepreneurial orientation and technological commercialization are key in the midst of economic reforms - drove an imperative for changes in governance mechanisms (Li *et al.*, 2008). The contingency theory has been used to explain why the adoption of responsive innovation policy HR policies by firms could be effective in development and implementation innovation strategies (Oke *et al.*, 2012). In addition, the *organizational resilience approach* and *resource dependency theory* have been employed to show how firms adopt defensive and safeguarding strategies to protect resource availability and competitive advantage like joint ventures, mergers and acquisitions (Hillman *et al.*, 2009) and strategic alliances (Park *et al.*, 2002) in an environment of turbulence.

Uncertainty

Strategic foresight in general and *scenario planning* in particular are used extensively as theories to address uncertainty in strategic decision making. Bowman et al. (2013) show that stories related in the scenario planning can help managers to deal with critical uncertainties that may face the organization in the future. They (the stories) can communicate and characterize uncertainties (Kwakkel *et al.*, 2013), and detect emerging opportunities and threats in technology, and predict the possible impact of change (Vecchiato and Roveda, 2010). *Real options theory* sees the application of financial options theory in the creation of options to provide more flexibility (Brouthers *et al.*, 2008). It balances commitment versus flexibility when individuals and organization are faced with uncertainty (Pacheco-De-Almeida *et al.*, 2008). Real options can even improve on quantitative evaluations in decision making (Verdu *et al.*, 2012).

Figure 1 shows the range of theories, their frequencies in our selected papers, and how they have been grouped against the themes outlined above to understand and explain decision making under uncertainty.

 Insert Figure 1 here

RESEARCH METHODS

Given the multidisciplinary nature of decision making and strategy under uncertainty with the complexity of the variables, relationships and contexts involved in this area a systematic review was necessary bring focus and understanding We followed the strategy and stages set by (Deyer & Tranfield, 2009; Tranfield, Deyer & Smart, 2003) to perform this systematic review. Accordingly we followed the stages of: planning the review,

conducting the review and reporting the results (Tranfield *et al.*, 2003). During our planning stage, we developed and refined our review protocol, research question and objectives in discussion with our panel of experts. The discussion was guided by the practical knowledge, theories and small scoping literature searches. This was as standard in the systematic review process and particularly important given the wide scope knowledge and sub-fields in the area of decision making and strategy under uncertainty. The review protocol produced at the end of this stage was a plan for the next two stages and helped us to maintain objectivity in the search. In addition, it included the population of our study, the search strategy and the criteria used to include and exclude the articles we analysed in our study. This resulted in the development of the keywords and search terms we used in conducting the literature search for the review.

The search for the relevant literature was done using mainly Thomas Reuters's Web of Science Core Collection database and supplemented by Elsevier's Scopus. The vast array of results was reduced by applying filters for deciding the inclusion and exclusion of articles to be taken forward for review. These filters which were the combinations of keywords and their derivatives of the elements outlined earlier were used in our search: 1) innovation and uncertainty, 2) decision making and uncertainty, 3) organizations and uncertainty, 4) strategy and uncertainty and 5) competency and uncertainty.

The keywords 'innovation', 'strategy and organization' and 'competency' were used as proxies for exploring and understanding decision making under uncertainty. The proxies of innovation (Leyden *et al.*, 2014); strategy (Behrens *et al.*, 2014); organizations (issues and conditions) (Van de Vrande *et al.*, 2009), and competency (Autio *et al.*, 2011) have all been shown in past discussions and studies on decision making in uncertainty.

The resulting sets from the two-word combinations were further merged with searches on the journals within which the articles were published, from Grades 3 and 4, from

across all fields in the Association of Business Schools Academic Journals Quality Guide 2015 because “not all of the journals have the same currency for management scholars” (Homberg and Bui, 2013, p. 460). Due to space limitations, a full list of journals is available from the author[s] on request.

We searched articles between 2000 and 2015. This fifteen year period represented a period of high uncertainty in the international business community, including increase in globalization and the financial crash of 2008 and the resulting economic downturn and this period would surely produce articles related to the area of enquiry

Articles were then excluded from the list if: a) they were too focussed on decision making in a narrowly focussed functional business area, at a product/service level, too industry specific or country specific e.g. marketing, new product development, semiconductors or China; b) they took a purely quantitative methodological approach to decision making; c) they focussed mainly on small business and founder entrepreneurs; and d) any of the keywords were used as ordinary words in the writing of the article. The article must be focussed on the strategic decision making at the organizational level and the processes through which these decisions were taken.

Based on the criteria above, after filtering 1814 collected papers, 135 ones were included for our final analysis. The articles and how they were group after an initial coding round are provided upon request.

The analysis was carried out using NVivo 10. The use of a software tool improves the rigor and depth of qualitative analysis (Nair et al., 2011). The analysis was further strengthened by using both inductive and deductive coding approaches with NVivo since this facilitates a rich thematic analysis and helps find themes and patterns across large areas of qualitative data (Fereday and Muir-Cochrane, 2006). The analysis of the articles initially started with the themes drawn from the keywords - i.e. decision making, uncertainty,

organization and strategy and competency - and expanded inductively from the review of the articles to the main parent (nodes). Themes used in the final coding were actions, performance, outcomes and success; competency and capabilities; culture; decision making; innovation; investment; levels of examination; organizations; perception, cognition and psychology; social context; theoretical framework; and uncertainty. Sub (child nodes) themes related to the main themes were added as we progressed through the review to facilitate further depth of analysis.

Figure 2 shows a tree map using the analysis of NVivo and created by yED Graph Editor to make it visually understandable. The tree map provides a snapshot of the depth and complexity of the coding of all the articles (items) in relation to the main themes and sub-themes. Table 1 shows the theories that were used in the papers against the themes outlined. Where appropriate, we further classified each theoretical theme based on whether it mainly addressed the individual, the organization or the external environment in its formulation.

Insert Figure 2 and Table 1 here

DECISION MAKING UNDER UNCERTAINTY CONTEXTS

Context is a crucial consideration because it has an influence on the decision making process and the final outcomes (Gharajedaghi, 2011). Context merges the considerations of such elements like organizational culture, structures, processes, individual psychology and cognition with an organization's functions (Butler et al., 2015). The external environment of the firm contributes to the integrative approach crucial for the modern firm (Desai, 2014; Hillman et al., 2009). In our analysis, we were able to classify four main contexts related to decision making under uncertainty; these are discussed below.

International and National culture contexts

With the growth of multinational enterprises (MNEs), organizational structures need to be flexible given the turbulent nature of international markets (Lewin and Volberda, 1999). An example of this is the operation of the same functional (flexible) teams across different countries with the need for these to switch between centralized and decentralized modes of decision making (Christensen and Knudsen, 2008). With the globalization process, international and national cultural values can have a significant impact on the TMT in the home country (Dimitratos *et al.*, 2011), and the strategic decision making process (SDMP) of the whole firm in the host country (Nummela *et al.*, 2014). In taking account of national culture and institutions representing national culture, cultural dimensions such as uncertainty avoidance and power distance need to be considered (Mueller *et al.*, 2013).

These dimensions can influence the entrepreneurial orientation and risk taking propensities of multinational corporation employees (Stevens and Dykes, 2013) and small and medium-sized enterprise (SME) entrepreneurship (Kreiser *et al.*, 2010). Operations and business engagements with companies in transition or with developing countries such as China (Li *et al.*, 2008) and Vietnam (Orr and Scott, 2008) represent other sources of challenge. For example, understanding the drivers and incentives required to promote entrepreneurial orientation and technological commercialization by TMT from such countries might present management issues for MNEs or national innovation policy challenges for these countries (Li *et al.*, 2008).

Social and Institutional contexts

Institutional rules, norms and societal beliefs and values, particularly when they interfere with innovation or business operations can influence uncertainty over decision making. For example, government regulation can have a strong impact on investment decisions, and can

have a significant impact on future operations and performance of a firm (Hoffmann *et al.*, 2009). Social cultural values can also play a role in the perception of the effectiveness of the managerial strategy and tactics applied with their employees, particularly given societal beliefs such as social cynicism, religiosity and fate control (Fu *et al.*, 2004). Lee and Park (2008) show strong evidence of the impact of TMT international exposure on international alliance formation. And when coupled with different national culture dimensions, institutional dimensions are likely to heighten uncertainty (Orr and Scott, 2008). The institutional context of a country's entrepreneurial efforts towards growth industries can be positively related to financial and educational activities and negatively related to corruption in mitigating the uncertainty of entrepreneurship (Bowen and De Clercq, 2008).

Functional and Organizational Contexts

On the one hand, in the functional areas of the firm, particularly in R&D and innovation, uncertainty tends to be very high for a number of reasons. For example, although R&D projects represent opportunities for growth and profitability, they are associated with high financial risk and rewards (McMullen and Shepherd, 2006). Other R&D areas include the fuzzy end of product or service innovation (Stevens, 2014), in the decisions of whether to exploit an R&D project against such considerations of the market, technology and finances (Oriani and Sobrero, 2008). Another reason can be the seniority level of the managers who assess the viability of R&D projects (Behrens *et al.*, 2014).

On the other hand, organizational structures have changed to more flexible and less bureaucratic structures to adapt their cross-boundary practices to adapt their cross-boundary practices to the uncertainties associated with an increasingly fast-paced and complex environment (Kellogg *et al.*, 2006). The supply chain function and its agility have become a source of potential competitive advantage for firms (Chiang *et al.*, 2012). New product

development and the development of new industries present not only opportunities to enter new markets but also challenges for the existing competencies and mental models (Benner and Tripsas, 2012).

Strategy-related Contexts

Strategy-related contexts refer to a broad area of strategic management. For example, new firms in high technology-knowledge-intensive industries may face with investment costs for resources, competencies and operational knowledge, the decision on whether or not to use outsourcing, or decisions on the choice and benefits of using a supplier network (Bhalla and Terjesen, 2013). Partnerships and alliances can also impact performance and both represent increased risk and uncertainty (Collet and Philippe, 2014). Failure is yet another strategic context which generate uncertainty which a firm has to respond to. Failure across an industry or market represents a challenge to an organization because of the contagion effect and it must develop a response to it in terms of strategy, operations and relationships (Rerup, 2009). Even the international strategic decisions like the choice of entry to a new market and sizeable investment involved can be an unnerving decision (Brouthers *et al.*, 2008). Strategy innovation tends to increase as a result of the uncertainty of international firms doing business in physically distant markets in foreign countries (Azar and Drogendijk, 2014).

Long-term strategic planning and its tools like scenario planning have been employed to inform and develop strategies to deal with future environmental uncertainty (Bowman *et al.*, 2013) and to develop new business models (Heger and Rohrbeck, 2012). Functional diversity (Qian *et al.*, 2013) or international experience of TMT (Piaskowska and Trojanowski, 2014) can have an impact on the uncertainty that the firm experiences and how it deals with it. Governance structure tends to provide flexibility advantages to an

organization and proves to be effective from a contingency perspective when there is uncertainty (Scherpereel, 2008).

Ultimately the international and national culture context affects the uncertainty that firms face because it may require different organizational policies, ways of communicating, difference combination of HR reward and motivation practices across different locations. This can present a challenge of new learning, process, procedures and flexibility from home country managers. Additionally, social and institutional context presents the uncertainty challenge of on the one hand pursuing good management practices but recognising that these may have to be compromised when faced with the force of strong social and institutional norms. Linkages of two or more of the context greatly increase the level of uncertainty since it increases the complexity of the interventions to address the increase complexity of the solutions needed to address the uncertainty. For example a host country developing HR employee reward policies (functional and organizational context), in a home country (international and national culture context) which differs in the an acceptance of what may appear as corrupt practices (social and institutional context), to drive sales and entrepreneurship (strategy context) may have to deal with the eventual uncertainty that results in the eventual policy in practice.

DIMENSIONS OF UNCERTAINTY

Uncertainty is not a uniform phenomenon but has many dimensions. These dimensions could be further categorized by layers depending on the unit of examination. A diagrammatic snapshot of the dimensions and layers of uncertainty in organizations is shown in Figure 3.

Contexts and Manifestation of Uncertainty

The contexts and manifestation of the occurrence of uncertainty explain the types of uncertainty which need to be considered in a particular context. For example, in innovation and R&D projects, a number of uncertainties need to be considered including financial, technological, and demand uncertainties (Behrens *et al.*, 2014). A firm's decision to enter a new market with new products or services can potentially bring high levels of market and competitive uncertainties (Calantone *et al.*, 2010). When firms enter foreign markets they are likely at the very least to face environmental uncertainty due to national culture differences (Dimitratos *et al.*, 2011). Cultural traits differences in terms of uncertainty avoidance and entrepreneurial orientation can impact on innovation in the firm (Kreiser *et al.*, 2010). In terms of organizational behaviour, a culture of psychological safety is important in giving employees a sense of freedom and helping to reduce anxiety which promotes experimentation and innovation when operating in uncertain and ambiguous environments (Lee *et al.*, 2004). Political and regulatory uncertainty can also impact on the market and operational activities of the firm (Brouthers *et al.*, 2008).

Insert Figure 3 here

Nature and Classification of Uncertainty

Certain attention has been paid to define the nature of uncertainty, particularly to the distinction between uncertainty and risk. Uncertainty has been employed to describe the lack of the ability of a firm to sufficiently predict or assess adequate probability in relation to future events; it has also been applied to the ability or otherwise to ascertain a cause-and-effect relationship (Lengnick-Hall and Beck, 2005). Duncan (1972) used lack of

information as one of the factors producing uncertainty, while Milliken (1987) went further and classified uncertainty according to the nature, effect, and response depending on how and where the uncertainty arises in the environment. Still others have described the multidimensional nature of environmental uncertainty by classifying the dimensions of complexity, frequency and unpredictability of resource variation (Heger and Rohrbeck, 2009).

Risk has traditionally been associated with uncertainty in management (Miller, 2007) and the two terms are used interchangeably. Risk is associated with known probabilities of events happening in the future, while uncertainty occurs when probabilities are not known (Knight, 1921). To further highlight the distinction, Miller (2007) argued that entrepreneurs achieve higher returns from the markets because they take advantage of uncertainty rather than risk which the market factors into its returns. Risk management as part of the strategic planning process represents the firm's response to different types of risk and is a way of dealing with uncertainty (Noy, 1998).

Increasingly with the growth of complexity in global business, there has been a new distinction to represent heightened uncertainty in different areas of hypercompetition (Thomas and D'Aveni, 2009) and jolts (Meyer, 1982). In certain industries like mobile phones and digital cameras, this can further feed hypercompetition (Benner and Tripsas, 2012). In looking at unlikely events that occurred post-2008 (after the financial and economic crash), more attention has been paid to understanding the phenomena of "black swans" and "unknown unknowns" and how they can be taken into account in foresight planning (Feduzi and Runde, 2014). Complexity and the 'science of complex systems' are now increasingly used, given the nature of problems and associated uncertainty brought on by the interconnection between natural, social and economic systems (Wilkinson *et al.*, 2013).

Both private and public sectors are dealing with such complex issues as climate change, or the impact of conflicts on the movement and availability of resources.

Human Factor

The final dimension in looking at uncertainty is the human factor including such characteristics as cognition, rationality, perceptions, behaviours, beliefs, intuition and attitudes that all play a role in the decision making process. Cognition - including intuition and effectual reasoning in the face of a risky and an ambiguous environment - has a great influence on entrepreneurship or new product development (McKelvie *et al.*, 2011). Mental models, cognitive bias and risky choice-framing all figure in the planning and decision making that take place under uncertainty, and their influence on the process must be understood and taken into account (Neill and York, 2012). Degree of rationality also plays a role in the individual's and organization's equation of uncertainty particularly as it is characterized by incomplete or insufficient information and their perceptions of and attitudes to risk and reward (Shimizu, 2007). Perceptions about uncertainty play a key part in managerial psychological input in the process of strategic decision making and how they view the surrounding environment (Ashill and Jobber, 2010).

In addition, individual behaviour and how it influences information gathering is also a key variable in areas of conflicts and novelty characterized by high uncertainty (Czernatowicz-Kukuczka *et al.*, 2014). Beliefs can greatly influence one's willingness and ability to integrate new data in a highly uncertain environment (Starbuck, 2009). The intuition of CEOs and TMTs has been shown to work alongside rationality in their strategic decision making in complex situations (Woiceshyn, 2009). Entrepreneurial attitude and beliefs are also considered important in understanding differences in individual managerial approaches (Qiu, 2008).

Observing the dimensions of uncertainty working together as would occur in practice, we propose that the origin of the uncertainty can occur either in the human factor dimension

(HFD) by a perception of uncertainty or in the contexts and manifestations of uncertainty dimension (CMUD) with an actual event which elicits a human or organizational response to the uncertainty. The CMUD is the same as the decision making under uncertainty contexts discussed previously. With the information gathered from the specific component of the CMUD this is then filtered through the different facets of the HFD from which an assessment is made of a specific component or combination of components of the nature and classification of uncertainty dimension (NCUD). This assessment process is important since it can determine perceptions, decision making, judgements and strategies to deal with a response to the uncertainty. The process of gaining more information and further assessment is repeated across the three dimensions until the decision maker(s) has decided they have enough information to make a decision as to the necessary response needed to address the uncertainty or the a response is required before all the information has been acquired.

DECISION MAKING UNDER UNCERTAINTY FRAMEWORK

The strategy for decision making under uncertainty has engendered wide ranging and intense examination, from human resource systems and their role in business strategy (Miles and Snow, 1984), to the micro- and macro-environmental impacts on strategy and competition (Porter 1991, 1998) and the continuing discussion of ‘rational’ decision making based on expectancy utility theory versus a behavioural approach to strategy (Levinthal, 2011). Based on the analysis of the decision making contexts and dimensions of uncertainty we have developed a framework showing the relationship between themes of decision making process, decisions and strategies (Figure 4). We explain the framework below.

Insert Figure 4 here

The role of the overall resources of the firm. Managers tend to consider the resources of the firm to develop strategies that will lead to competitive advantage and long-term performance (Dimitratos *et al.*, 2011). The power of resources and the constant desire to acquire and maintain them to reduce environmental uncertainty drives firms to adopt resource-dependence strategies and actions (Hillman *et al.*, 2009). The RBV has been extended beyond competitive advantage to explain the above normal profits particularly under value uncertainty due to imperfect knowledge of the individuals in the firm about the value of the resources (Becerra, 2008). Resource variation in an uncertain environment can generate internal turbulence on the return value of the resources, and consequently, affect the market entry decision of the firm (Dowell and Killaly, 2009). Decision making effectiveness and performance in innovative projects can be mediated by reflexivity within the teams (Hammedi *et al.*, 2011).

Knowledge and learning as key resources. Successful organizational learning to drive the decision making process over time draws on a range of competencies and capabilities to deal with potential uncertainties (Ellis and Shpielberg, 2003). Knowledge and learning are crucial for the firm since combined, these have an influence on the firm's competitive advantage, strategic capability, flexibility and performance (Santos-Vijande *et al.*, 2012). Knowledge development as part of a learning organization is important to ensure competitiveness in turbulent environments (Suikki *et al.*, 2006).

In environmental and technological uncertainty, learning mechanism such as scanning units, small-scale experimentation and quality circles which provide information to the firm and helps it to acquire new knowledge bases has been shown to decrease perceived uncertainty (Ellis and Shpielberg, 2003). In decision making effectiveness especially in international entry mode decision, knowledge and learning are important components to

drive effectiveness (Ji and Dimitratos, 2013). Scenario planning is a widely used learning tool in strategic planning and decision making (Meissner and Wulf, 2013).

Corporate venturing is another learning strategy that firms often employ to assess their options with high financial investments in high technological ventures (Van de Vrande and Vanhaverbeke, 2013). MacKay and Chia (2013) suggested that when following environmental determinism where firms must find the right fit with the environment, firms must learn and adapt aggressively, or their survival will be threatened. With its conceptual basis within the RBV, the resilience perspective is one of the organizational learning components. It has been used in strategic management to deal with such threats as counter-terrorism (Sullivan-Taylor and Wilson, 2009).

Competencies, dynamic capabilities and fit as key considerations in the maintenance of competitive advantage. The outcomes of the strategy and decision making processes in a changing business environment tend to be the firm's continuous renewal of its competencies and dynamic capabilities, and its strategic flexibility to maintain its competitive advantage (Chiang et al., 2012). This strategy requires constant renewal of resources to prevent imitation by competitors, which leads to resource accumulation and can result in competitive advantage through this accumulation (Pacheco-De-Almeida *et al.*, 2008).

According to Zajac et al. (2000), strategic fit is important when formulating strategy. It is associated with a strategy of developing routines, which are linked to the capabilities of the firm to deal with stable anticipated change - i.e. equilibrium-to-equilibrium shifts - and to use it to reduce complexity (Judge and Blocker, 2008; Lengnick-Hall and Beck, 2005). However, Lengnick-Hall and Beck (2005) suggested that when the nature of the uncertainty is complex, continuous, and not marked by returns to equilibrium, firms have to adopt robust transformation instead of adaptive fit.

The impact of human resources and individual characteristics. Another key resource that is employed to address uncertainty is the person-organization-environment fit (Beal and YasaiArdekani, 2000). In a changing and complex environment, the skills and knowledge of managers are crucial in the decision making and strategy processes (Strandholm *et al.*, 2004). In turbulent environments of uncertainty, a cross-functional TMT can have a positive impact on the strategic orientation and performance of a firm (Cannella *et al.*, 2008); and in particular the CEO can have an impact on the TMT potency and the structures and processes of the firm in delivering results in the anticipated environment (Carmeli *et al.*, 2011). Additionally, the demographic factors such as education and experience of the TMT can influence the perceptions of the members which in turn influence their strategic preferences (Patzelt *et al.*, 2009). International experience of managers will also influence international orientation and a firm's international strategy in such areas as acquisitions and market expansion (Piaskowska and Trojanowski, 2014).

Furthermore, the top human capital and composition has an effect on corporate entrepreneurship (Heavey and Simsek, 2013). Innovative leadership and HR practices and policies have also been seen to be important in innovation strategy (Oke *et al.*, 2012) and driving innovation projects particularly in encouraging collaboration across all functions in the organization in innovation projects (Stock *et al.*, 2014).

Individual cognition, rationality and mental models and how they inform the process. Mental models simplify the complexity and breadth of the information which managers with their limited cognitive abilities need in their strategic decision making processes (Dimitratos *et al.*, 2011; Simon, 1979). Decision making and its effectiveness can greatly influence the mental models of managers (Hammedi *et al.*, 2011). For example, it has been argued that in highly uncertain situations, transformational and charismatic leadership are tied to cognition since these types of leadership trigger the brain centres to

associate with intellectual stimulation (Ensley et al., 2006; Waldman et al., 2004). Sinclair and Askanasy (2005) proposed that individuals should employ two parallel cognitive systems (rational-analytical and experiential-intuitive) in decision making in uncertain and ambiguous conditions to process information. The two-system process together with the cognitive traits of focus, motivation and self-awareness plays a role in helping CEOs to manage complex situations (Woiceshyn, 2009). Uncertainty-driven cognition linked to organizational adaption and the cognition-based view with its basis in perceptions of goals and actions have been used to explain capability development in entrepreneurship (Autio *et al.*, 2011).

Intuition, beliefs and their influences on cognition and framing of individuals.

The variation in cognition response in decision making under uncertainty is further explained by individual differences in the need for closure, behavioural inhibition system and working memory capacity, and how these influence one another when there is the dilemma of the search involving a large quantity of available information (Czernatowicz-Kukuczka *et al.*, 2014). Intuition tends to play a significant role in the judgments of employees in go/no decisions in industries requiring high investment. It is employed when there is incomplete information, and when there are differences in the rules employed by experts across different subject areas in the decision making process (Cowlrick *et al.*, 2011). Additionally, belief as in ‘opportunity beliefs’ (Shepherd, 2015) and passion for work and non-work-related excitement (Klaukien *et al.*, 2013) can influence entrepreneurial cognition.

The role of creativity and trust. Creativity and abstract thinking borne out by psychological distance has been shown to increase creative cognition and facilitate the understanding of novel information and assessing of creative ideas (Mueller *et al.*, 2014). Team knowledge management of stock and utilization impacts in different ways based on the cognitive styles of the leaders, and the effect shows a relationship with organizational

performance (Sung and Choi, 2012). Creativity is encouraged by relational trust, which can bring both positive and negative effects in the entrepreneurial activities of large firms since they have an impact on the vulnerability of decision makers to pursue appropriate courses of action in the presence of ambiguity and social complexity (Zahra *et al.*, 2006).

The components of the framework outlined above identify and outline specific relationships between some of the firm's key competencies, capabilities and resources (CCR) as outlined in dynamic capabilities (Teece *et al.*, 1997). It addresses a criticism of a need for clarification of dynamic criticism (Ambrosini & Bowman, 2009; Barreto, 2010; Easterby-Smith, Lyles & Peteraf, 2009; Peteraf, 2013). It goes further by explicitly outlining the role and presence of uncertainty, with its dimensions and how the CCR can influence strategies and decision making in an environment of uncertainty. In addition, the framework recognises that uncertainty is not a uniform phenomenon and that the contexts of the uncertainty will determine the unique decision making process and strategic combination of CCR needed to respond to the particular source of uncertainty.

CONTRIBUTIONS AND FUTURE RESEARCH DIRECTIONS

This study has drawn together the disparate research on decision making under uncertainty across various subject areas and presented a systematic approach to the complexities of this important area. We have documented and classified the theoretical concepts used in addressing the research questions to an integrated and layered explanation. From the integrated framework that has been developed, we present elements and considerations which have implications for decision making under uncertainty when developing strategies. These implications are important given the fact that as the climate of decision making has become increasingly competitive and uncertain, there is a need for all companies and organizations to remain agile and responsive (Doz and Kosonen, 2008).

Running parallel with this there is a rise in non-Western countries attracting and purchasing highly talented professionals and resources; along with increasing government regulations and knowledge and innovation diffusion (Schulze *et al.*, 2015). As a result of the study we identify several research gaps and future directions.

First, it would be interesting to test whether or not the variables in the developed framework act similarly across industries, organizational settings and national cultural settings to understand the differences, and how these variations work. As Gregoire *et al.* (2011) stated, the level of analysis of cognition related to environment is important across different levels, as it might reveal both similarities and differences across industries and countries.

Second, over the past decades, researchers have recognized that single theoretical foundations have been inadequate in explaining decision making and resulting strategies under uncertainty and they have increasingly combined two theories (McKelvie *et al.*, 2011). However they rarely combine three different theories from the different themes such as those that we have discussed. Given that the increasing complexity of decision making is bringing greater uncertainty, there is a need to draw out the relationships from various themes, and adopt and test theoretical frameworks that are adopted from the above four themes (psychology, cognitive and social; competencies, capabilities and resources; organization; and uncertainty) we have developed to classify the theoretical foundations of this study.

Third, exploring the role that certain individual competencies have in dealing with an environment of uncertainty may be an interesting line of result of research. In particular, researchers might test Hayton and Kelley's (2006) propositions around individual competencies of brokering, sponsoring and championing in corporate entrepreneurship on managers who operate in such environments. The results from this type of study could then

inform the job description proficiency sections and the candidate assessment process as part of the recruitment for managers in these types of roles. In addition, it could also be a consideration when developing professional development plans for such managers.

Fourth, following on from the previous point, future research could explore and test whether performance in decision making under uncertainty in a business setting can be taught and whether the accepted expectation for extensive experience is necessary (Miller, 2012). Both Morris et al., (2013) and Aharoni et al., (2011) have advocated education as a basis to raise and improve competencies in decision making in two areas of uncertainty *entrepreneurship* and *international business*.

Although systematic reviews are of significantly value due to the breadth of the examination and the objective way it is carried out compared to normal literature review, there are, as expected, some limitations. First, as part of our strategy to focus our papers on relevant sources in order to remain objective, we used a set of criteria to include relevant papers in the review and others. Although strategy-led, this process is of a subjective nature since the screening was led by the authors. Second, given the vast breadth of the area of decision making under uncertainty, it is inevitable that some studies and papers may have been inadvertently missed. Finally, with a unique study such as this one which is multidisciplinary and broad in the approach of the topic, there may have been lapses in assessing the results and implications compared to the case when assessing a more defined topic.

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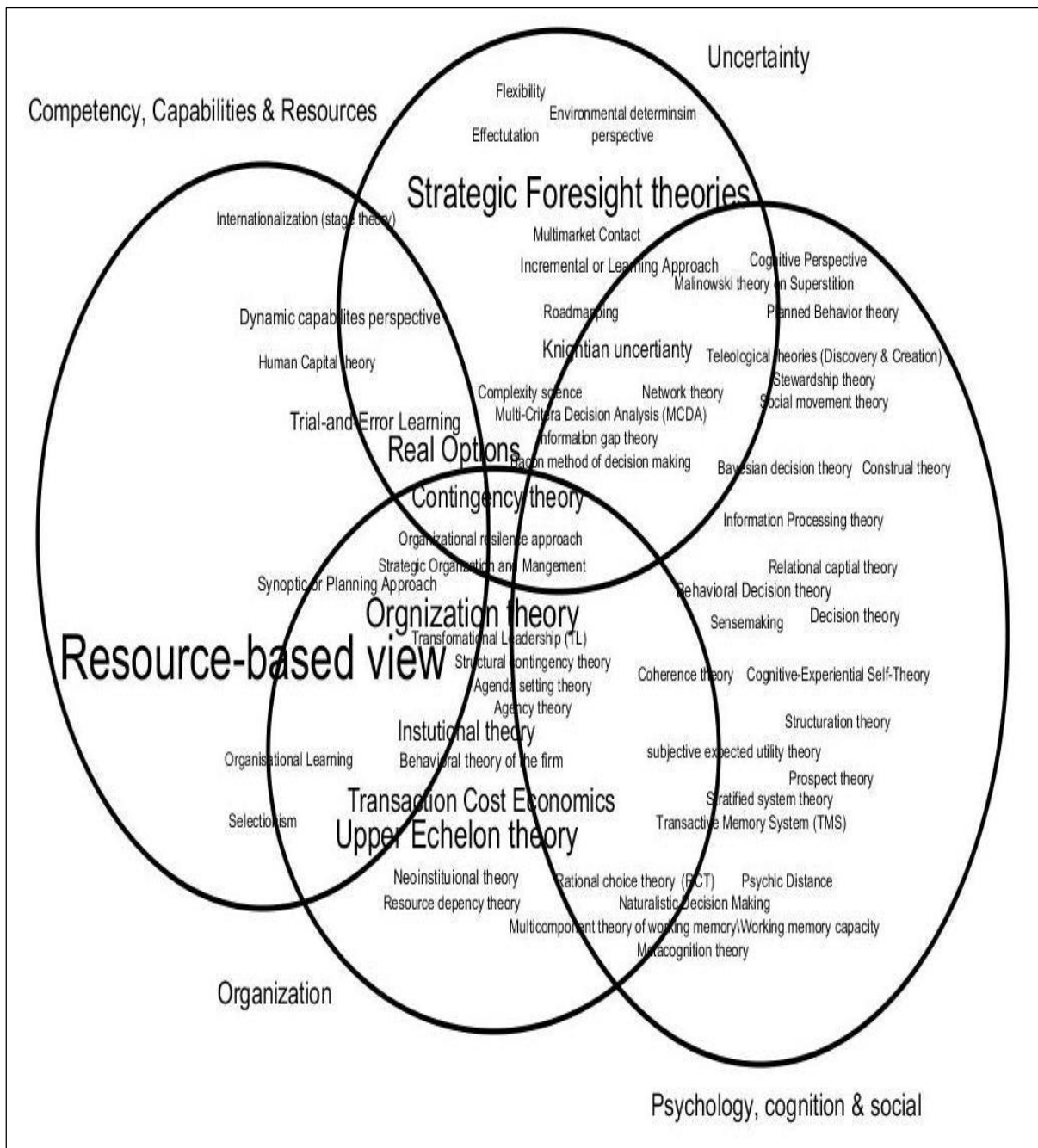
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Figure 1 - Word Cloud of Range of Theories and Themes Classification



The size of the font represents the frequency in which the theoretical framework was used across all the papers. The positioning and closeness of the theories represents the grouping of them. The largest number of papers coded against one theoretical framework is 20 the smallest 1.

Figure 2 - Treemap of Coding Frequency of Papers at Main and 1st level Sub themes

thematic



Figure 3 - A snapshot of the dimensions and layers of uncertainty in the organization.

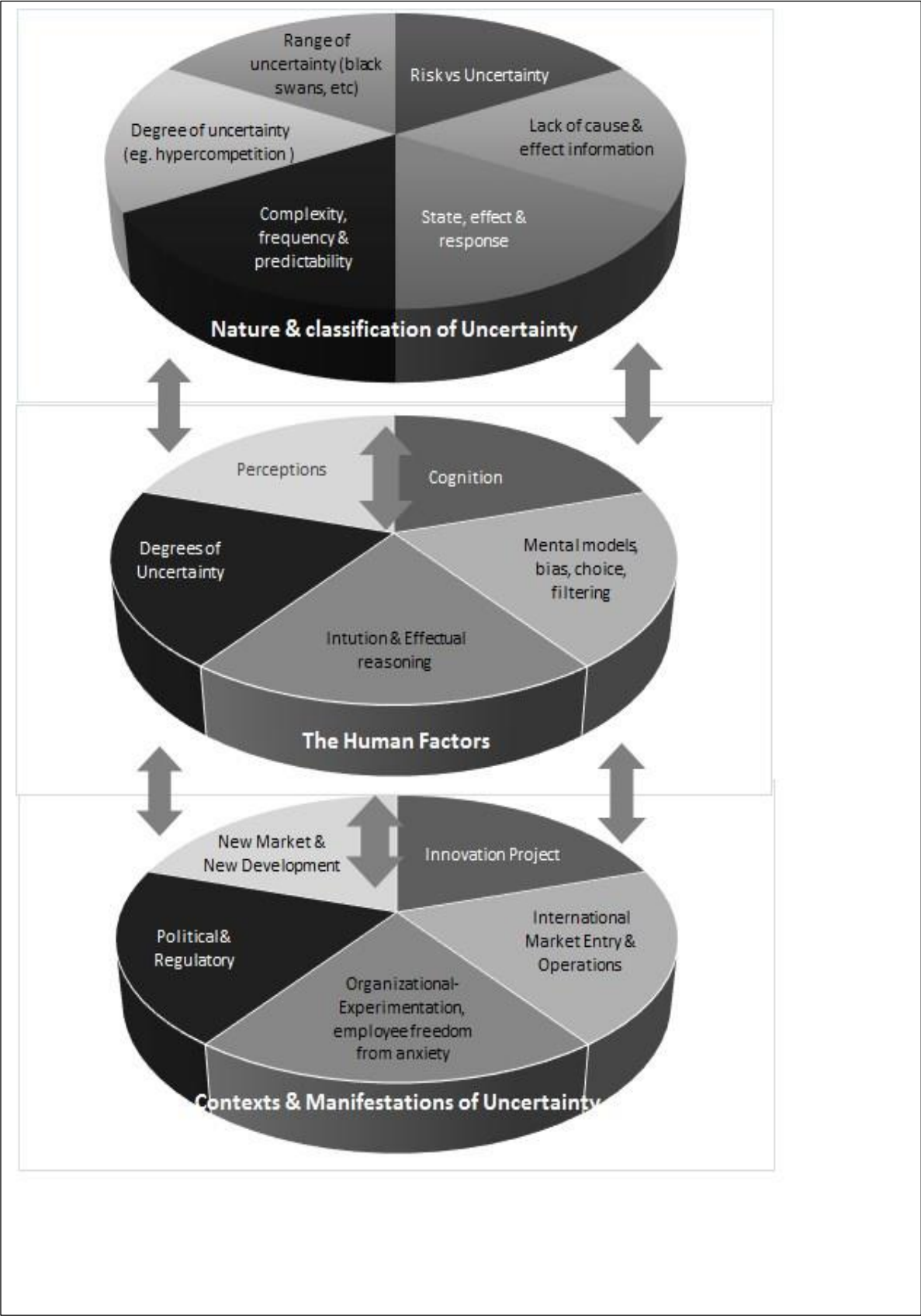


Figure 4 - Framework showing the relationship between themes, decision making process and decisions & strategies.

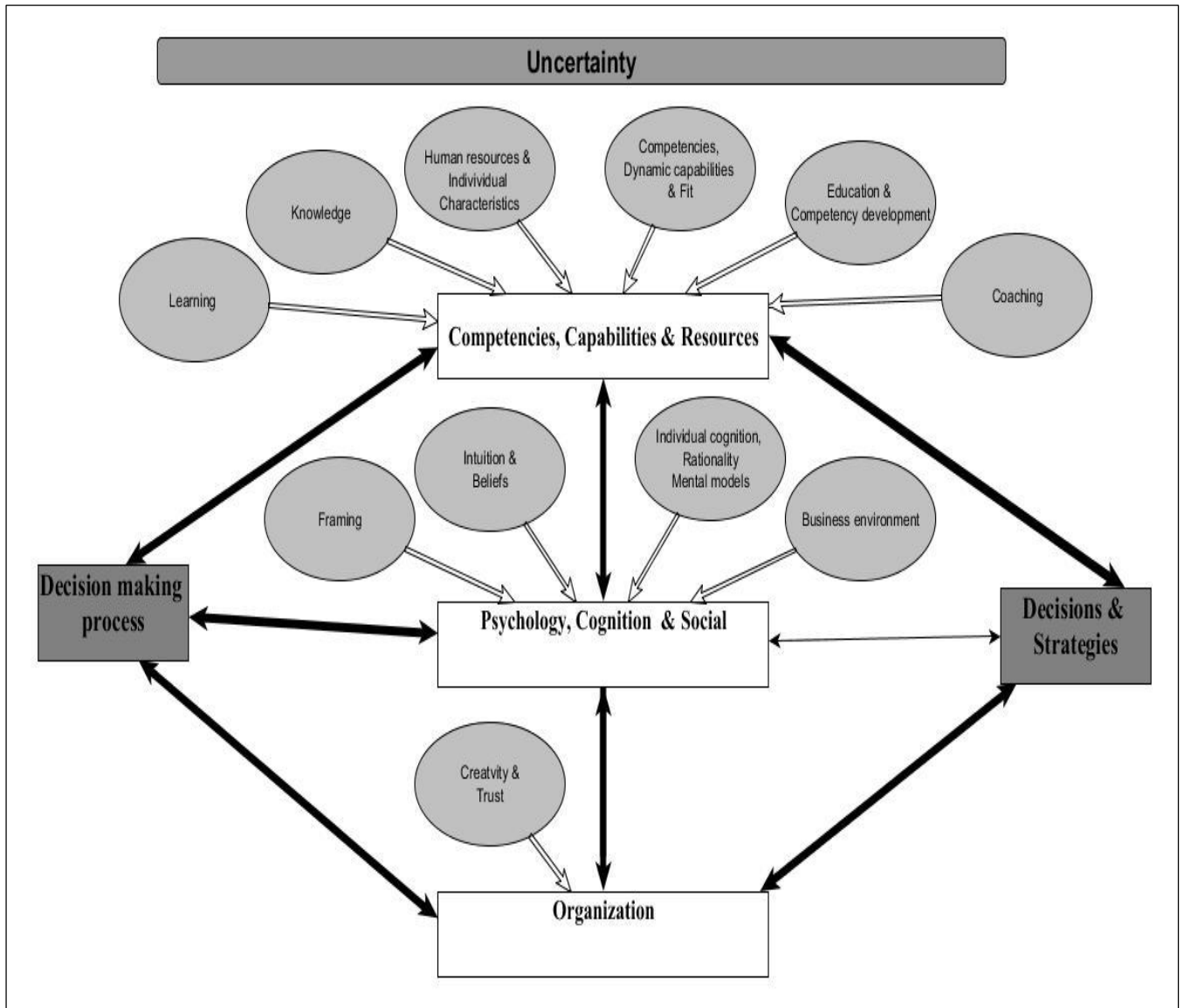


Table 2 - Theoretical foundations classified across coding themes

Coding Schemes	Theoretical Foundation				
Competencies, Capabilities & Resources	Resource-based -view Organizational capacity for change (OCC)	Competence-capabilities perspective Upper Echelon theory	Dynamic capabilities perspective Internationalization (stage theory)	Trial-and-Error learning Selectionism Human capital theory	Transformational Leadership Organizational Learning
Psychology, Cognitive & Social Context	Transformational Leadership Organizational Learning Institutional theory Behavioural theory of the firm Behavioural Decision Theory Subjective Expected	Psychic Distance Naturalistic Decision Making Multicomponent theory of working memory Metacognition theory Malinowski theory on Superstition Creation theory	Decision making Schools Construal theory Coherence theory Cognitive-Experiential Self-Theory Bayesian decision theory Multimarket contact Structuration Utility theory	Sensemaking Reasoned action theory or Planned Behaviour theory Prospect theory Information Processing Theory Cognitive perspective Stratified system theory	Transactive Memory System (TMS) Teleological theories (Discovery & Creation) Stewardship theory Social movement theory Rational choice theory (RCT)
Organization	Contingency Theory Structural contingency theory	Organizational resilience approach Agenda setting theory	Environmental determinism perspective	Transaction Cost Economics Agency theory	Institutionalist perspective Strategic organization and management
Uncertainty	Scenario planning Synoptic or Planning Approach Flexibility Road mapping	Real options theory Real options theory\strategic real options Real options theory\operative real options	Real options\Commitment or Inflexibility Knightian uncertainty Effectuation Decision theory Complexity science	Network theory Multi- Criteria Decision Analysis Information gap theory	Discovery driven planning Bacon method of decision making Multimarket contact\Mutual Forbearance