AMBIGUITY AVERSION

IN THE FRONT-END OF INNOVATION

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Abstract: There have been repeated appeals for further scientific inquiry into the early stages of innovation in the firm, referred to as the front-end of innovation. Currently, we lack a clear understanding of front-end decision-making processes. Conceptually, the front-end stages of innovation are likely to include decisions involving ambiguity rather than risk. One way to view the innovation process is that considerable effort is expended on risk-reduction. That is to say, the innovation/new product development process converts amorphous ideas into tangible products that have a maximum chance of success in the commercial marketplace. However, this may lead to a preference for advancing product concepts where risk, in terms of clear probabilities, can be more easily established. At the same time, those new ideas and product concepts that are ambiguous may be discarded or screened out simply because it seems difficult to discover the probability estimates associated with their outcome success. This is ambiguity aversion, and it has been found to be an important predictor of decision making under uncertainty. Using a framework based on decision theory and the theory of expected utility, I propose and test a model in which ambiguity aversion has a detrimental effect on the performance of front-end innovation activities due to a suppression of decision-making comprehensiveness. Innovation culture and innovative capacity also play important roles in the success of front-end innovation activities. The data is collected from a sample of managers ($N = 175$) with active roles in innovation management. In summary, the results of a revised model serves to provide a valuable framework through which firms and managers can improve front-end of innovation performance. Multiple directions for future research are also discussed.

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NOMENCLATURE

p	p value
α	Cronbach's (coefficient) alpha
β	Beta coefficient
χ^2	Chi-square

ABBREVIATIONS

3SLS	Three stage least squares
AA	Ambiguity aversion
AGFI	Adjusted goodness of fit index
AVE	Average variance extracted
CAPI	Capacity to innovate
CFA	Confirmatory factor analysis
CFI	Comparative fit index
CR	Construct reliability
CVF	Competing Values Framework
df	Degrees of freedom
DMC	Decision-making comprehensiveness
EFA	Exploratory factor analysis
FNE	Fear of negative evaluation
FPA	Front-end of innovation performance, attribute version
FPS	Front-end of innovation performance, subjective version
GFI	Goodness of fit index
ICL	Innovation culture
MSE	Mean square error
NFI	Bentler-Bonett index or Normed fit index
NNFI	Tucker Lewis index or Non-normed fit index
NPD	New-product development
OC	Organizational culture
p.a.	Per annum
PCOMP	Perceived competence
RMSEA	Root means square error of approximation
SRMR	Standardized root mean square residual

CHAPTER I

INTRODUCTION

1.1. Front-End of Innovation and Ambiguity Aversion

Innovation allows for firms to gain competitive and strategic advantages, while ensuring long-term growth and survival (Brown and Eisenhardt 1995; Chandy and Tellis 1998). Innovation is also critical in allowing firms to find solution to problems or developing new ideas and serves to change both market and competitive landscapes. As a result, scholars have expended great effort in to the study of innovation (e.g. Hauser, Tellis and Griffin 2006; Chandy and Tellis 1998; Damanpour 1991; Montoya-Weiss and Calantone 1994). This research activity has attempted to understand various facets of innovation: including product innovation, process innovation, how firms organize for innovation, the technological dimension of innovation, and the antecedents and consequences of innovation etc.

Given the importance of product innovation (Cooper 2001; Griffin 1997), there is demand to understand how innovation is executed within a firm. This dissertation is interested in the new product development activities that firms engage in. Based on the direction of both extant research and practice, innovation in firms can be divided into three major parts; the front-end, new-product development, and commercialization. Collectively this is referred to as the new-product development process. The new-product development process suggests that new ideas are generated at the front-end, further developed during the new-product development stage, and ultimately enter the marketplace through commercialization.

In terms of research intensity, the new-product development and commercialization stages have received a majority of the attention (Hauser, Tellis and Griffin 2006). Scholarly work has developed well-respected scientific models that explain these stages in addition to making numerous recommendations for best practice. However, inquiry into the front-end has been lacking. The term '*fuzzy front-end*' of innovation was first coined by Reinertsen (1985), and quickly achieved widespread acceptance as a term to describe the early, pre-developmental work in the new-product development process. The term *fuzzy* captures the inherent vagueness associated with the front-end of innovation. Aspects of the early stages of the new-product development process are characterized as being difficult to evaluate, lacking accountability, challenging to explain and model, and generally lacking understanding.

It is this aspect of the new-product development process that the current dissertation is interested in exploring. The front-end of innovation can be properly

defined as “those activities that come before formal and well-structured new-product development portion” (Koen, et al. 2001, p. 49). One way to contemplate this would be to think about the front-end as comprising of all those activities that precede actual design and engineering effort. Routine front-end activities include idea generation, opportunity recognition, and concept definition. When compared to the new-product development stage, there are multiple facets that differentiate the front-end. However the degree of uncertainty present in each stage is of particular interest to this dissertation.

There exists a high degree of uncertainty pertaining to many aspects of the front-end of innovation (Cooper 2001; Koen, et al. 2001). Since new ideas and product concepts in the front-end are far from launch and early in development terms, firms often find it arduous to find relevant information to make well-informed decisions on the scope of the project, its financial viability, and ultimate competitiveness etc. Hence we say that there exists a high degree of uncertainty at the front-end.

How individual project managers react to this uncertainty can have an important impact on front-end innovation performance, and since innovation is a sequential process, it could also impact firm performance. To best of my knowledge, this is the first study that attempts to understand these relationships. However, in order to further examine these issues, it is important to gain a clearer understanding of uncertainty and how people react to it.

In terms of uncertainty, Knight (1921) first pointed out the fact that there is both measurable uncertainty and unmeasurable uncertainty. He called the former risk and the latter was described as ambiguity. According to Knight (1921), since risk is observable it

can be quantified. Therefore risk is often described in terms of known probabilities while ambiguity is described in terms of unknown probabilities. Research attempting to better understand uncertainty, has often been drawn to risk rather than ambiguity because of its measurable or observable quality. Phenomenon involving ambiguity however has been less explored. Regardless, both have been singled out as important parameters in decision-making (Trautmann, et al. 2008).

Ambiguous situations are those where "available information is scanty or obviously unreliable or highly conflicting; or where expectations of different individuals differ widely; or where expressed confidence in estimates tends to be low" (Ellsberg 1961, p. 660-61). This description clearly fits the front-end of innovation. As mentioned previously, the front-end is characterized as having a lot of uncertainty, and to be more specific it is dominated by ambiguity rather than risk. As a result, the front-end stages of innovation are likely to include decisions involving ambiguity rather than risk. Therefore, it becomes important to understand the role of ambiguity in decision-making.

Interestingly, it has been found that individual decision-making is different when dealing with ambiguity and risk. Ellsberg (1961) found that people, when given a choice, are more likely to choose a riskier bet with known probabilities as opposed to a less risky one in which the probabilities are ambiguous. Ellsberg (1961) exhibited this phenomenon in a number of simple experiments, the most famous of which is widely referred to as the 'two-color' problem. Given two urns each containing a hundred balls, a study participant is told that the first urn contains 50 red and 50 black balls and that the second urn contains red and black balls in an unknown proportion. Ellsberg (1961) demonstrated that when a participant is offered a reward depending on the outcome from

randomly drawing the balls, participants (while indifferent on betting either red or black balls for either urn) were more likely to bet on the first urn (with the known composition) rather than the second urn (with the unknown composition). In other words, study participants exhibited a preference for gambles with known (risky) rather than unknown (ambiguous) probabilities of winning (Muthukrishnan et al. 2009; Ellsberg 1961).

This experiment suggests behavior that is inconsistent with expected utility theory and is referred to as the Ellsberg's paradox. The decision-making phenomenon exhibited in Ellsberg's paradox has become known as ambiguity aversion. Trautmann et al. (2008, p.225) define ambiguity aversion as situations where people "prefer options involving clear probabilities (risk) to options involving vague probabilities (ambiguity)." As such, it is a decision-maker's ambiguity aversion that ought to be studied in terms of its impact on the front-end of innovation. This is exactly what this dissertation sets out to do.

1.2. Purpose of the Study

The purpose of this dissertation is to study the role and impact of a decision-maker's ambiguity aversion on the front-end of innovation. It is clear that innovation plays an important role in firm performance and competitiveness. With this in mind, there have been repeated appeals for further scientific inquiry into the early stages of innovation in the firm, referred to as the front-end of innovation. Currently, we lack a clear understanding of front-end decision-making processes.

Conceptually, the front-end stages of innovation are likely to include decisions involving ambiguity rather than risk. One way to view the innovation process is that considerable effort is expended on risk-reduction. That is to say, the innovation/new

product development process converts amorphous ideas into tangible products that have a maximum chance of success in the commercial marketplace. However, this may lead to a preference for advancing product concepts where risk, in terms of clear probabilities, can be more easily established. At the same time, those new ideas and product concepts that are ambiguous may be discarded or screened out simply because it seems difficult to discover the probability estimates associated with their outcome success.

This is what I have described earlier as ambiguity aversion, and it has been found to be an important predictor of decision making under uncertainty. My goal is to propose and test a theoretical model in which ambiguity aversion has a detrimental effect on the performance of front-end innovation activities.

As such the pertinent research questions are:

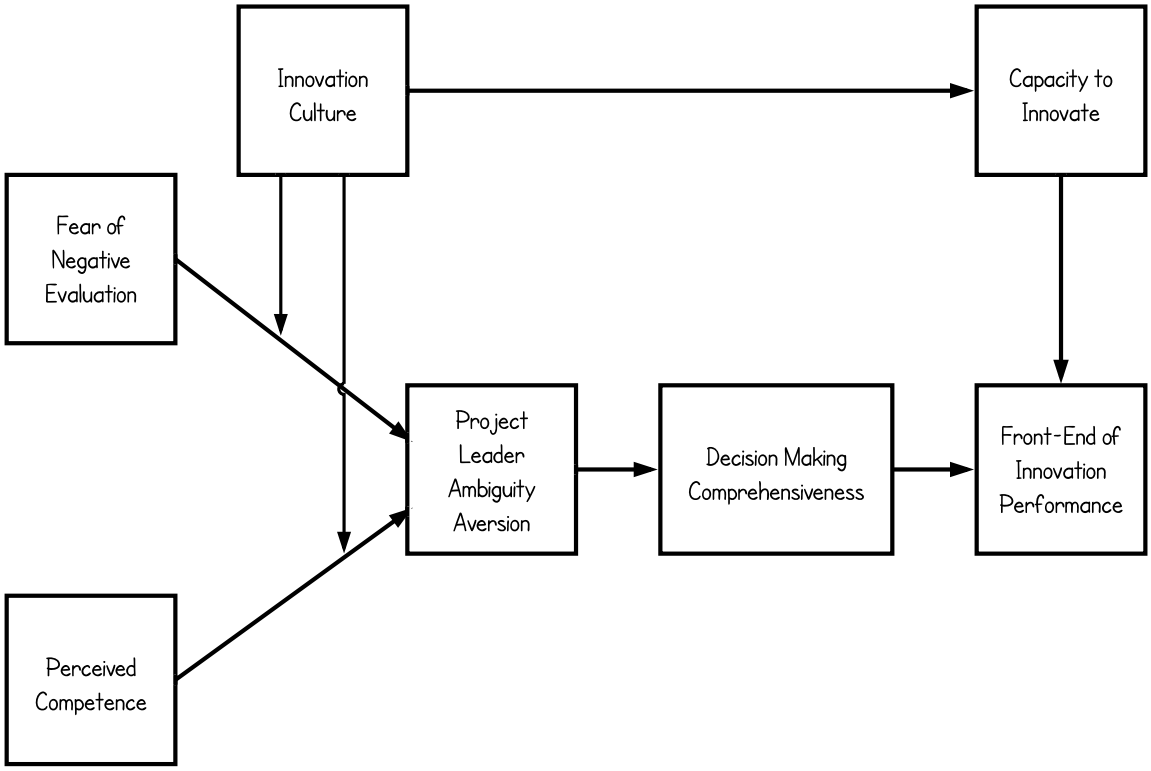
1. What leads to a situation where a decision-maker exhibits ambiguity aversion?
2. Does a decision-maker's ambiguity aversion impact front-end innovation performance? If so,
3. Under what circumstances can the impact of ambiguity aversion on the front-end of innovation be managed?

1.3. Proposed Model

In asking the research questions mentioned previously, I develop a conceptual model that attempts to answer them. As shown in Figure 1-1, the model posits a complex relationship between a project leader's ambiguity aversion and front-end of innovation

performance. All the proposed relationships are based on a comprehensive review of the literature.

Figure 1-1 – The Conceptual Model



I suggest that there are two important antecedents to a project manager's level of ambiguity aversion. Fear of negative evaluation, which is the perceived fear of negative evaluation by others, post decision, and perceived competence which reflects an individual's willingness to choose an uncertain event dependent on his/her competence over the decision context. Interestingly, and never before conceptualized, I suggest that

innovation culture plays an important moderating role between ambiguity aversion and its antecedents.

Ambiguity aversion impacts front-end of innovation via decision-making comprehensiveness. Decision-making comprehensiveness is defined as "the degree to which the team is exhaustive as it considers multiple approaches, courses of action, and decision criteria in its strategic decision making" (Slotegraaf and Atuahene-Gima 2011, p. 97). While the relationship between decision-making comprehensiveness and innovation performance is well established, few have adequately described its antecedents. This dissertation suggests that a project leader's ambiguity aversion serves as an important antecedent to the decision-making comprehensiveness of new product teams. The conceptual model suggests that ambiguity aversion has a negative impact on front-end of innovation performance due to a suppression of decision-making comprehensiveness. Innovation culture also has an important impact on innovation performance which is mediated by the firm's capacity to innovate.

1.4. Theoretical Significance

The current study attempts to make relevant contributions to the science of marketing because it adds not only to our understanding of the front-end of innovation but also in regards to important decision-making phenomenon. It studies the underexplored connection between the ambiguity literature and innovation literature. In terms of the front-end of innovation, this study will contribute to theory by providing an in depth look at decision-making processes that are involved. In terms of decision-making, the study will help clarify our theoretical foundations on decisions involving

uncertainty— especially ambiguity. This dissertation fills an important theoretical gap that will ultimately allow for a better understanding of this phenomenon going forward.

1.5. Managerial Significance

From a managerial perspective, this dissertation makes important normative recommendations that could potentially have widespread significance. There have been repeated calls from industry to provide a better understanding and recommendations for activities that make up the front-end of innovation. The current study heeds this call by analyzing the role of ambiguity aversion in such contexts.

A decision-maker's aversion to ambiguity could have detrimental effects—especially in terms of innovation. This dissertation will provide managers with a clearer understanding of why this is the case. At the same time, the results of the study should help decipher how and when such negative impacts can be controlled or regulated. These findings could potentially be generalized to contexts other than innovation, thus increasing its significance to managers.

1.6. Organization of the Dissertation

The dissertation is organized into six chapters. This chapter, the first, provides a brief overview of the purpose, conceptual model, and theoretical and practical significance of the study. Chapter II provides a review of the relevant literature from the new product development, organizational culture, and risk and uncertainty literatures. The section reviewing the literature on risk and uncertainty pays particular attention to ambiguity. Chapter III then sets out the proposed conceptual model and develops eight

testable hypotheses. Chapter IV outlines the research methods for measuring, collecting, and analyzing the data. In this study, date will be collected from new product project leaders using survey methods. Chapter V then presents the results of the analysis including the measurement model, the analytical model, and the hypothesis testing. Chapter VI then discusses the findings, reconciles these findings with prior research, and makes suggestions for future research.

CHAPTER II

REVIEW OF LITERATURE

2.1. Introduction

This chapter serves as an in depth review of the relevant literature. The chapter has three major sections. The first reviews the literature relevant to innovation. Here I provide a broad overview of the scholarly work conducted in regards to innovation. This is followed by a discussion of the important antecedents to successful innovation in firms. A focus on the front-end of innovation in addition to antecedents considered important to positive front-end performance wraps up the section.

The second section of the literature review is focused on organizational culture. This review provides the reader with an overview of extant research on organizational culture especially related to the domain of marketing. I outline the competing values framework that serves as a categorization schema for various types of firm cultures. The section concludes with a through discussion on innovation culture.

The third section of the literature review focuses on ambiguity and ambiguity aversion. The major scope of this dissertation lies in relating the literature on ambiguity aversion to activities that are conducted in terms of innovation. This review is critical in developing a majority of the propositions outlined in the next chapter. The section initially discusses ambiguity then proceeds to a discussion on ambiguity aversion followed by its antecedents. This is followed by a review comparing ambiguity to risk and ambiguity aversion to risk aversion. The chapter concludes with a brief summary.

2.2. Literature on Innovation

The subsequent subsections provide a thorough overview of the literature on innovation. I begin by discussing innovation within a broad context followed by a discussion of the antecedents of new-product development. This is followed by a focused review of the extant literature on the front-end of innovation. Here I make it clear how the front-end of innovation differs from the other stages of innovation. I also discuss the various antecedents of front-end of innovation that have been explored in prior literature.

2.2.1. Innovation

Innovation is a fundamental process that helps establish a competitive advantage within firms (Brown and Eisenhardt 1995). Through innovation, firms develop solutions to problems or discover new ideas. Thus, its impact can increase quality, add value, lower prices etc.; and thus provide benefits to the firm's customers. Innovation also drives change. When firms engage in innovation, it forces markets to change and adapt. Market participants that do not adapt will ultimately perish, and those that do will emerge

to be successful (Chandy and Tellis 1998). In addition, I argue, that change, serves as a driver of innovation. Firms innovate in response to changes in consumer preferences and lifestyles, to capitalize on newly emergent opportunities or defend against marketplace threats (Brown and Eisenhardt 1995).

As pointed out by multiple scholars, innovation is a focal point and driver of competitiveness in the marketplace, and as such, is a key area of research focus (Baregheh, Rowley and Sambrook 2009; Hauser, Tellis and Griffin 2006; Chandy and Tellis 1998). As evidenced by the wealth of research, it is clear that innovation is a broad topic. Scholars have focused on various facets of innovation including product innovation, process innovation, how firms organize for innovation, the technological dimension of innovation, and the antecedents and consequences of innovation etc. Below, I examine some of the major definitions of and types associated with innovation.

Schumpeter (1934, p.65) defines product innovation as the creation of a new good which more adequately satisfies existing or previously satisfied needs." Similarly, Utterback and Abernathy (1975, p.642) define a product innovation as "a new technology and or combination of technologies introduced commercially to meet a user or market need." More often than not, when people think of innovation, they are thinking about product innovations. This can be attributed to the fact that product innovation receives the majority of the limelight (compared to other types of innovation) and translates into financial and performance related variables. A good example of a product innovation is the MP3 player. It fits the definitional criteria set forth by Schumpeter and others. Product innovation can also be seen in service offerings. FedEx and UPS innovated to provide a better service for their consumers by offering overnight delivery service.

Table 2-1

SELECT DEFINITIONS OF *INNOVATION* FROM VARIOUS STREAMS OF LITERATURE

Author(s)	Stream	Definition
Schumpeter (1934)	Economics	"New combinations of new or existing knowledge, resources, equipment"
Thompson (1965)	Political Science	"the generation, acceptance and implementation of new ideas, processes, products, or services"
Mohr (1969)	Political Science	"the successful introduction into an applied situation of means or ends that are new to that situation"
Zaltman et al. (1973)	Marketing	"Any idea, practice, or material artifact perceived to be new by the relevant unit of adoption"
West and Farr (1990)	Management	"the intentional introduction and application within a role, group or organization of ideas, processes, products or procedures, new to the relevant unit of adoption, designed to significantly benefit the individual, the group, organization or wider society"
Damanpour (1991)	Management	"Adoption of an internally generated or purchased device, system, policy, program, process, product, or service that is new to the adopting organization"
Rogers (1995)	Marketing	"An idea, practice, or object that is perceived as being new by an individual or other unit of adoption"
Nohria and Gulati (1996)	Management	"Any policy, structure, method or process, product or market opportunity that the manager of the innovating unit perceived to be new"
OECD (2005)	Economics	"A marketing innovation is the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing"
Crawford and Di Benedetto (2006)	Management	"the process of developing new products"

However innovation is not limited to changes in product-related attributes. Innovation can occur within activities related to the manufacture of products and services, or its distribution, and even in after sales service to name a few. Such innovations are called process innovations. A process innovation is defined as the "implementation of a new or significantly improved production or delivery method"

(OECD 2005, p. 32). Tushman and Nadler (1986, p. 77) define process innovation as changes to "the way products and services are made or delivered." Often times, with process innovation, the product or service may remain unchanged. However, there may be cost efficiencies and other benefits associated with process innovation. As pointed out by Trott (2008), process innovations are key not only in terms of production, distribution etc., but also in terms of the managerial decision making processes related to the product (such as the new product development process).

Scholars have also attempted to better understand the degrees (or levels) of innovation. It should be noted that some innovations, be it product- or process-innovations, are radical or major breakthroughs. On the other hand, a vast majority of innovations are more incremental in nature, often providing smaller benefits. As pointed out by Chandy and Tellis (1998), the degree or level of innovation is based on newness of technology along with the added benefit or value provided to the customer. A radical innovation has been defined as those that "involve substantially new technology and provide substantially greater customer benefits per dollar, relative to existing products" (Chandy and Tellis 1998, p.476). On the opposite end of the spectrum, an incremental innovation "involve relatively minor changes in technology and provide relatively low incremental customer benefits per dollar" (Chandy and Tellis 1998, p. 476). Garcia and Calantone (2002) have suggested that a simple radical vs. incremental dichotomization does not adequately capture the various levels of innovation. They have suggested a third level that explains innovations that fall in between radical and incremental and call it "really new innovation." Likewise, terms such as drastic innovation (Reinganum 1985), revolutionary innovation (Caselli 1999), and disruptive innovation (Govindarajan and

Kopalle 2006) have been used to describe various level of innovation in terms of their effect on the marketplace.

Radical innovation, specifically, has received a lot of scholarly attention over the past decade (Tellis, Prabhu and Chandy 2009; Sorescu and Spanjol 2008; Sood and Tellis 2005; Sorescu, Chandy and Prabhu 2003). Studies have suggested that firms that successfully develop radical innovations tend to attain dominant positions in the marketplace based on higher profitability and market share (Atuahene-Gima 2005, Tellis and Golder 2001). Failure to produce radical innovations can bring down large incumbents (Chandy and Tellis 2000). As a result, CEOs and managers have begun to realize the important role of radical innovation (Yadav, Prabhu and Chandy 2007). However, there is a high degree of uncertainty surrounding radical innovation (Leifer et al. 2000).

In light of the importance of innovation, academic scholars have expended considerable effort in an attempt to understand how firms should organize themselves in order to increase their ability to innovate. As such, organizational/firm factors such as structure and culture (including role of management, project team organization, cross-functional collaboration etc.) are key to understanding innovation within firms.

Organizational structure, broadly defined as how the organization puts its various work units together to accomplish its goals, provides multiple avenues to enhance innovative capability (O'Reilly and Tushman 2004; Dougherty 1999). While firms tend to be good at generating new ideas, the process of seeing them through to commercialization is difficult at best, and this difficulty is often blamed on poor structure

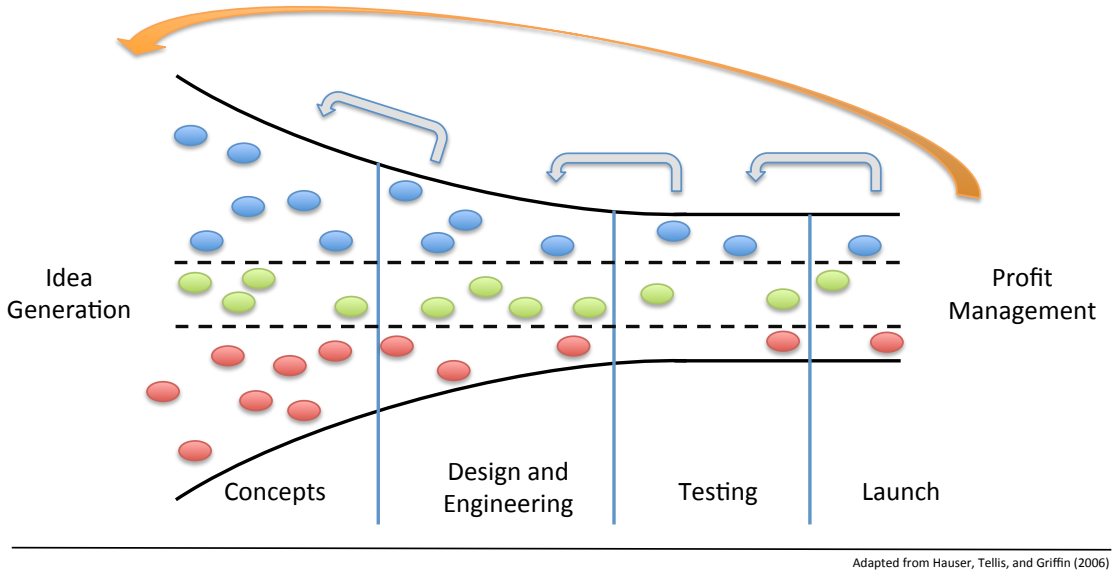
(O'Reilly and Tushman 2004; Daft 2007). Terms such as agile, adaptive, risk-taking, flexible and ambidextrous are often used to describe organizational structures best suited to innovate (Tellis, Prabhu and Chandy 2009; O'Reilly and Tushman 2004; Zien and Buckler 1997). Relatedly, scholars have also found that organizational culture plays an important role in determining a firm's innovative capabilities (see sections 2.3.1. and 2.3.2.).

As emphasized earlier, innovation is key to firm success. In particular, product innovations seem to be of most importance to the survival and prosperity of the modern corporation (Cooper 2001; Griffin 1997). Therefore, it is important to understand how innovation is executed within firms. Current trends in practice, and recommendations from scholarly work, suggest that innovation in firms is divided into three major parts; front-end innovation, new-product development and commercialization (collectively referred to as the new-product development process, *cf.* Griffin 1997; Brown and Eisenhardt 1995; Montoya-Weiss and Calantone 1994). In other words, newly generated ideas move through stages that ultimately result in a product offering which is hopefully innovative.

Firms are more successful at generating new ideas, than at seeing them through to launch. In other words, for each single successful new-product launch, failures are many (Hauser, Tellis and Griffin 2006). As a result of this, the new-product development process is often characterized as a funnel (refer to Figure 2-1). New ideas and opportunities enter through the mouth of the funnel, and go through various stages such as design and engineering, concept testing etc., before finally being launched. The product development funnel aptly shows that not all ideas make it through to launch,

many ideas will fail, though some might be recycled and improved. In addition, visualizing the new-product development process in this manner, helps to recognize that, firms have a higher likelihood of introducing successful innovative products if they have a multitude of projects (product concepts) in the funnel at any given time (Hauser, Tellis and Griffin 2006; Cooper 1994).

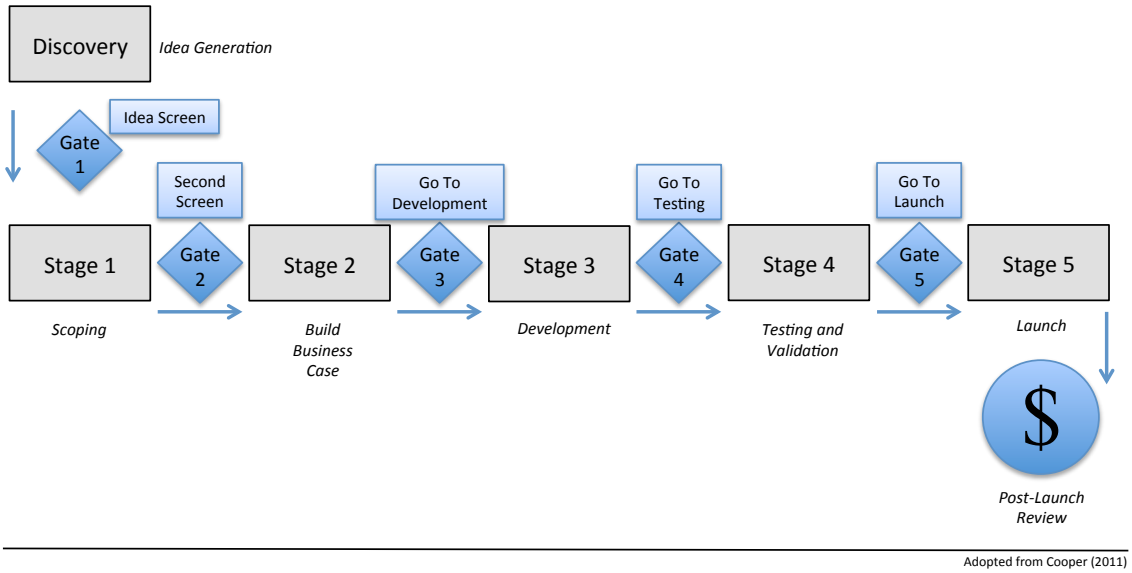
Figure 2-1 - Product Development Funnel



In applied practice, the concepts behind the new-product development funnel have been developed and adopted (by a vast majority of firms) as the Stage-Gate® system. The Stage-Gate® system, which has been widely adopted among innovative firms (Cooper, Edgett and Kleinschmidt 2005), serves as a good tool to describe the new-product development process in further detail. The Stage-Gate® system commits all of a firms new ideas through a systems of stages and gates (see Figure 2-2). The stages involve a set of prescribed, often cross-functional, and parallel activities that have to be performed (Cooper 2001). While the stages indicate a certain process or set of tasks that

has to be performed to the concept, gates are check points that serve as go/kill decision points (Cooper 2001). Gates also serve a quality control function as entrances to subsequent stages. Unless certain pre-specified criteria are met, the product concept cannot advance to the next stage (Cooper 2001).

Figure 2-2 - The Stage-Gate® System



While Stage-Gate® has received wide-spread attention, there are other innovation management approaches that have been prescribed as alternative 'game-plans' to the new-product development process. One of these is the spiral process (Boehm 1988; Garnsey and Wright 1990). A spiral process for new-product development values speed as a key part of the process. Project teams quickly examine concepts with each successive pass, and swiftly pass them through to the next stage of development. As concepts are moved from one stage to the next, the process should attain greater speed. A claimed advantage of the spiral process is that its use lowers costs associated with the new-product development process. Research has found that the spiral process is well

suited to firms facing a high degree of technological and market turbulence (Cusumano and Yoffie 1998).

Another alternative model of new-product development suggests overlapping stages (Cooper 1994). As an example, design activities might commence even before an idea is completely hashed out. While the Stage-Gate® model remains the popular choice in prescribed 'game-plans' for new-product development, Hauser, Tellis and Griffin (2006) have advocated further research in alternative innovation management systems and processes to new-product development.

2.2.2. Antecedents to New-Product Development

In addition to the discussion on new-product development processes, multiple studies have attempted to understand and explain the antecedents that predict firm's success at the new-product development process, and innovation in general. This is important, since a firm's ability to successfully innovate via new-product conception, development and launch could decide the fate of the business (Cooper 2001). More specifically, these studies look at both product- and firm-level factors that predict firms' success at developing new novel ideas into a commercially successful and innovative product offerings. Brown and Eisenhardt's (1995) and Montoya-Weiss and Calantone's (1994) meta-analyses discuss antecedents to successful new-product development.

Product uniqueness and superiority are primary drivers of new-product development success at the product-level (Cooper 2001; Cooper and Kleinschmidt 1996). However, it should be pointed out, in turn uniqueness and superiority result from customer focus and being market driven. In other words, a strong market orientation in

addition to a global/world focus in product development has been found to determine success in new-product development (Cooper 2001; Han, Kim and Srivastava 1998; Narver, Slater and MacLachlan 2004).

Antecedents inherent to a successful new-product development process also include a strong emphasis on pre-development work (Cooper and Kleinschmidt 1996). Pre-development work involves all the activities that occur in the fuzzy front-end of innovation, that is before actual design and engineering commence. Such activities include preliminary market assessments, technical and financial feasibility studies etc. Part of this includes having an early, sharp product definition (Cooper 2001). A clearly defined product concept has been shown to be a key indicator of future product success. Other process-related antecedents for new-product development success include instituting tough go/kill decision points and overall top management support in facilitating the new-product development process (Montoya-Weiss and Calantone 1994; Cooper and Kleinschmidt 1996).

Finally, a third category of new-product development antecedents includes firm-level factors. Key among these is having an innovative culture, one that stresses the importance of new and innovative products (Montoya-Weiss and Calantone 1994; De Brentani and Kleinschmidt 2004; see section 2.3.2. for a wider discussion). As pointed out by Dobni (2008), an innovative culture emphasizes creating avenues for employees to create and innovate, recognizing their efforts, and defining the role of top management in the new-product development process as that of facilitators. Other firm-level antecedents to innovation success include the incorporation of specific strategies that guide a firm's product innovation activities, product team organization, and resource commitment

(Montoya-Weiss and Calantone 1994; Cooper and Kleinschmidt 1996).

2.2.3. Front-End of Innovation

As pointed out earlier, the innovation process in firms can be divided into three parts, the front-end, new-product development, and commercialization. While there has been an abundance of research activity focused on new-product development (see Brown and Eisenhardt 1995 and Montoya-Weiss and Calantone 1994), less attention has been focused specifically on the front-end of innovation.

The term '*fuzzy front-end*' of innovation was first coined by Reinertsen (1985), and quickly achieved widespread acceptance as a term to describe the early, pre-developmental work in the new-product development process. The term *fuzzy* captures the inherent vagueness associated with the front-end of innovation. Aspects of the early stages of the NPD process are characterized as being difficult to evaluate, lacking accountability, challenging to explain and model, and generally lacking understanding. However, more recently there has been a concerted effort to refrain from using the term *fuzzy* (Koen et al. 2002). Koen et al. (2001) were the first to refer to the early stages of innovation as simply the *front-end of innovation,* suggesting that the term fuzzy had too many unwarranted connotations. While this dissertation uses the term front-end innovation, in all regards it is interchangeable with *fuzzy front-end*.

In the preceding section, this dissertation provided an overview of the Stage-Gate® system which is used to describe the new-product development process. Within the Stage-Gate® system, the first three stages are referred to as the front-end of innovation (Cooper 2001; Koen et al. 2002). In Figure 2, the first stage is discovery,

characterized as the stage where there is an in-depth focus on the market, consumers' needs, and ultimately responsible for generating new ideas (or product concepts). The second stage in the Stage-Gate® system, called scoping, pertains to activities that are centered on performing early market feasibility studies and early technical assessments of the project (Cooper 2001). Both activities are performed to gain insight into the relative merits of the respective idea or product concept. The third stage, involves preparing an in-depth business case (Cooper 2001), where a majority of the pre-development work is conducted. This stage includes activities such as performing market research, developing a sharp and clear definition of the product, and providing the financial and other justification needed to advance the product concept to subsequent stages.

Describing the front-end of innovation in terms of the Stage-Gate® system is simply one approach to doing so. For example, Koen et al. (2001, p. 49) define the front-end of innovation as "those activities that come before the formal and well structured new-product development portion." An alternative definition, based on activities, suggests that the front-end "includes product strategy formulation and communication, opportunity identification and assessment, idea generation, product definition, project planning and executive reviews … (and the front-end) is complete when a business unit either commits to the funding and launch of a new product development project, or decides not to," (Khurana and Rosenthal 1998). Regardless of the descriptive approach, published research appears to have reached a consensus that front-end innovation precedes formal new-product development work such as designing and engineering (Koen et al 2001; Khurana and Rosenthal 1998).

Table 2-2

DIFFERENCES BETWEEN THE FRONT-END OF INNOVATION AND THE NEW-PRODUCT DEVELOPMENT PROCESS

	Front-End of Innovation	New-Product Development
Nature of work	Experimental, often chaotic. Difficult to plan. Eureka Moments.	Structured, disciplined and goal-oriented with a project plan.
Commercialization date	Unpredictable or uncertain.	High degree of certainty.
Funding	Variable. In the beginning phases many projects may be "boot legged" while others will need funding to proceed.	Budgeted.
Revenue expectations	Often uncertain with a great deal of speculation.	Predictable with increasing certainty, analysis, and documentation as the product release date gets closer.
Activity	Individuals and teams conducting research to minimize risk and optimize potential.	Multifunction product and/or process development team.

adapted from Koen et al. 2001

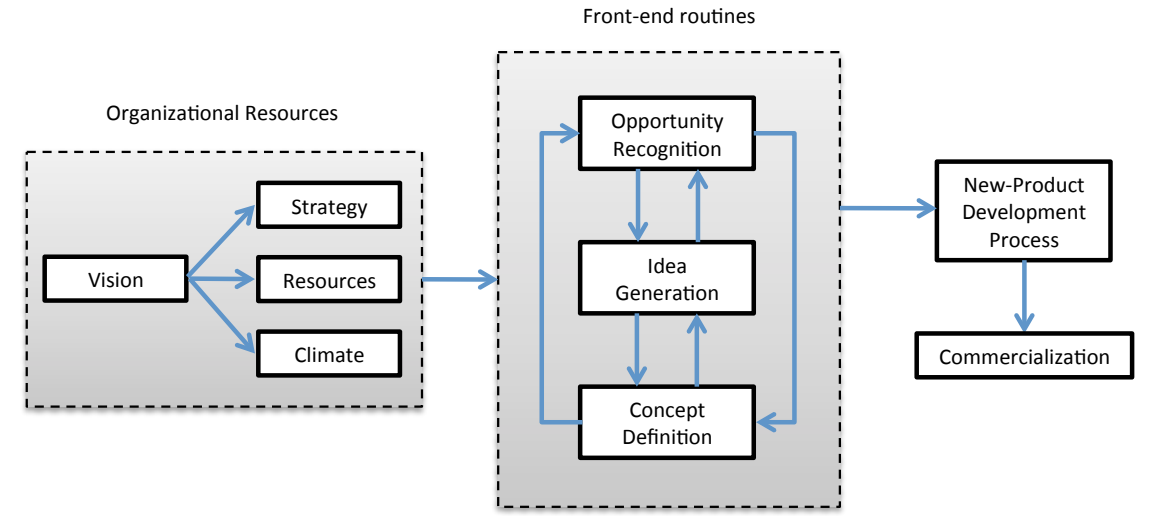
As outlined in Table 2-2, there are multiple delineating features between the front-end and new-product development. Of most significance to this dissertation, is the fact that, there exists a high degree of uncertainty pertaining to many aspects of the front-end of innovation (Cooper 2001; Koen et al. 2001). While on the other hand, activities performed in the new-product development stage are often defined as being well structured and formal (Koen et al. 2001), which often results in increasing certainty and predictability as products proceed through to the launch stage (Brown and Eisenhardt 1995; Montoya-Weiss and Calantone 1994). Since new ideas and product concepts in the front-end are far from launch and early in development terms, firms often find it arduous to find relevant information to make well-informed decisions on the scope of the project, its financial viability, and ultimate competitiveness etc. As a result, many have

advocated a more broad-minded and divergent approach to activities comprising the front-end of innovation (Koen et al 2001; Khurana and Rosenthal 1998).

Whereas, with activities that make up the new-product development stage, extant research encourages a more sequential and routinized approach (Cooper 2001). These fundamental differences between front-end innovation and the new-product development stages call for different managerial decision-making processes for each (Koen et al. 2001).

In addition to the general consensus in defining front-end activities as immediately preceding formal new-product development activities, another comparison in the literature is viewing the front-end via a more holistic approach rather than as a number of separate activities. Khurana and Rosenthal (1998), based on what they observed among successfully innovative organizations, were central to advocate a holistic view of the front-end of innovation (See Figure 2-3 below). Their approach captures the iterative nature of the front-end (Koen et al. 2001). Activities like opportunity recognition, idea generation and concept generation are undertaken simultaneously and are not mutually exclusive to each other. This is the main distinguishing feature between the holistic model of front-end innovation as compared to the Stage-Gate® system, which by definition are sequential stages (Koen et al. 2002; Cooper 2001).

Figure 2-3 - Holistic Model of Front-End of Innovation



Adopted from Koen and Bertels (2011)

Viewing innovation as a sequential process, moving from front-end activities to commercialization via new-product development efforts, early success in the process is key to ultimate success at the end. Early product concepts that have a high degree of innovativeness and scope are likely to emerge at launch intact with those attributes. On the other hand, product concepts or ideas that are poorly conceived at the front-end are highly likely to manifest at the end of the product development process as failures. Therefore, it is imperative to understand the antecedents that predict success at the front-end of innovation.

2.2.4. Antecedents to the Front-End of Innovation

Similar to the earlier discussion on new-product development, a number of academics have looked into what factors make for an effective front-end. According to Khurana and Rosenthal (1998) having a clear product strategy that helps prioritize key

projects early and aids in developing a portfolio of new products to balance risk and resources is an important antecedent that leads to success. Also an early definition of the product that is clear and sharp but recognizing that changes to the definition might be required later leads to success (Khurana and Rosenthal 1998). Additionally, Khurana and Rosenthal (1998) suggest that an organizational structure that emphasizes roles for the various individuals involved, that facilitates team work and cross-functional collaboration based on effective communications are all key antecedents to success at the front-end of innovation.

Some of the antecedents for effective new-product development (discussed earlier and) outlined by Cooper (2001) are more apt for front-end activities. For example, Cooper (2001) points out the importance of thorough up-front or pre-developmental work. By no means should companies approach activities that compromise the front-end with a nonchalant attitude, as this would certainly lead to failures. Following Khurana and Rosenthal (1998), Cooper (2001) also points to the importance of having a well-defined product concept as early as possible. Such definitions are characterized by descriptions of the product, including its features, and the intended audience.

Other antecedents that lead to front-end innovation success include a high level of market orientation (Langerak, Hultink and Robben 2004; Atuahene-Gima and Ko 2001). Firms that are market oriented recognize more opportunities and generate better ideas resulting in a higher success rate at front-end activities. Section 2.3.2., points out how the role of market orientation, as a culture, impacts innovation in firms. In a study of front-end innovation within Japanese firms, Verwon, Herstatt, and Naghira (2008) found that reduction of market and technical uncertainty predicted overall success in the front-end.

These studies suggest that strategic planning is positively correlated to new-product development performance, while pointing out that such planning is especially key at the front-end.

A separate category of antecedents common to successful front-end innovation and new-product development can be found in various indirectly linked streams of literature. These antecedents share a common trait in that they all stem from either project leader or team characteristics. An often-cited example of such an antecedent is project team (or product-development-team) stability (Slotegraaf and Atuahene-Gima 2011; Pelled, Eisenhardt and Xin 1999). Slotegraaf and Atuahene-Gima (2011, p. 97) describe project team stability as the "extent to which the core members of a cross-functional team remain for the duration of the project," from inception through launch. It has been suggested that team stability encourages collaborative work and open discussion, which allows cross-functional teams to break knowledge-barriers that hinder the innovation efforts of firms (Slotegraaf and Atuahene-Gima 2011; Dougherty 1992).

A related factor is collaboration, which leads to increased communication and openness among team members (Khurana and Rosenthal 1998; Scott and Bruce 1994; Pierce and Delbecq 1977). Collaboration (via openness and communication) stimulates an environment that is conducive to innovation by encouraging creativity, risk-taking initiative, and signals to team members that their contributions are highly valued thus making them care more about the innovative activities of the firm (Scott and Bruce 1994; Eisenberger, Fasolo and Davis-Mastro 1990; Pierce and Delbecq 1977). However, there is also evidence to suggest that in certain situations, conflict can breed innovation (Thompson 1965).

Another group of antecedents that factor into a firm's innovation performance (both at the front-end and new-product development stages) are related to learning and communication both internally and externally. Internally, it has been pointed out that factors, such as team level debate foster positive innovation within firms. Team level debate has been defined as the "deliberate process in which teams discuss, challenge, and contest one another's opinions, ideas, and positions about the project's strategies, goal priorities, and overall objectives" (Slotegraaf and Atuahene-Gima 2011, p. 96). External communication is also key, as it helps to generate and then disseminate information based on which project leaders and team members could develop further opportunities, better ideas etc. (Ancona and Caldwell 1992; Damanpour 1991; Cohen and Levinthal 1990).

A final category of antecedents discussed here relates to factors associated with decision-making and leadership traits. Decision-making comprehensiveness is discussed extensively as an important indicator of successful innovation (Slotegraaf and Atuahene-Gima 2011). Fredrickson (1984, p.445) studied decision-making comprehensiveness among top management teams and described it as "the extent to which organizations attempt to be exhaustive or inclusive in making and integrating strategic decisions." Multiple studies have discussed its role as an influential process undertaken by managers and their teams when making strategic choices (Simons, Pelled and Smith 1999; Miller, Burke and Glick 1998). Slotegraaf and Atuahene-Gima (2011) show that it is a key factor that influences innovation. They expand on Fredrickson's (1984) definition and define it as "the degree to which the team is exhaustive as it considers multiple approaches, courses of action, and decision criteria in its strategic decision making" (Slotegraaf and Atuahene-Gima 2011, p. 97).

Other scholars have studied concepts similar to decision-making comprehensiveness. For example, Damanpour (1991) points out the role of participative decision-making based on earlier work by Thompson (1965). Scott and Bruce (1994) discuss the importance of problem solving and the role of leadership in determining innovative behavior. Ultimately, the consensus in the related literature suggests that decision-making comprehensiveness is key to successful innovation in firms. It should be noted the team level debate (discussed earlier) and decision-making comprehensiveness are two separate variables, it is possible to debate without being comprehensive.

2.3. Literature on Culture

The following discussions are centered on firm culture. I first discuss the extant literature on organizational culture; especially those works based on the competing values framework. This is then followed by a focused look on attempts to understand innovation related culture in organizations. The discussion here has important implications on key moderating relationships found in the conceptual model.

2.3.1. Organizational Culture and the Competing Values Framework

Organizational culture is defined as "the pattern of shared values and beliefs that help individuals understand organizational functioning and that provide norms for behavior in the organization" (Deshpandé, Farley, and Webster 1993, p. 4).

As pointed out by Deshpandé and Webster (1989), organizational culture (OC) has fascinated Marketing scholars (and to a larger extent Management scholars) for

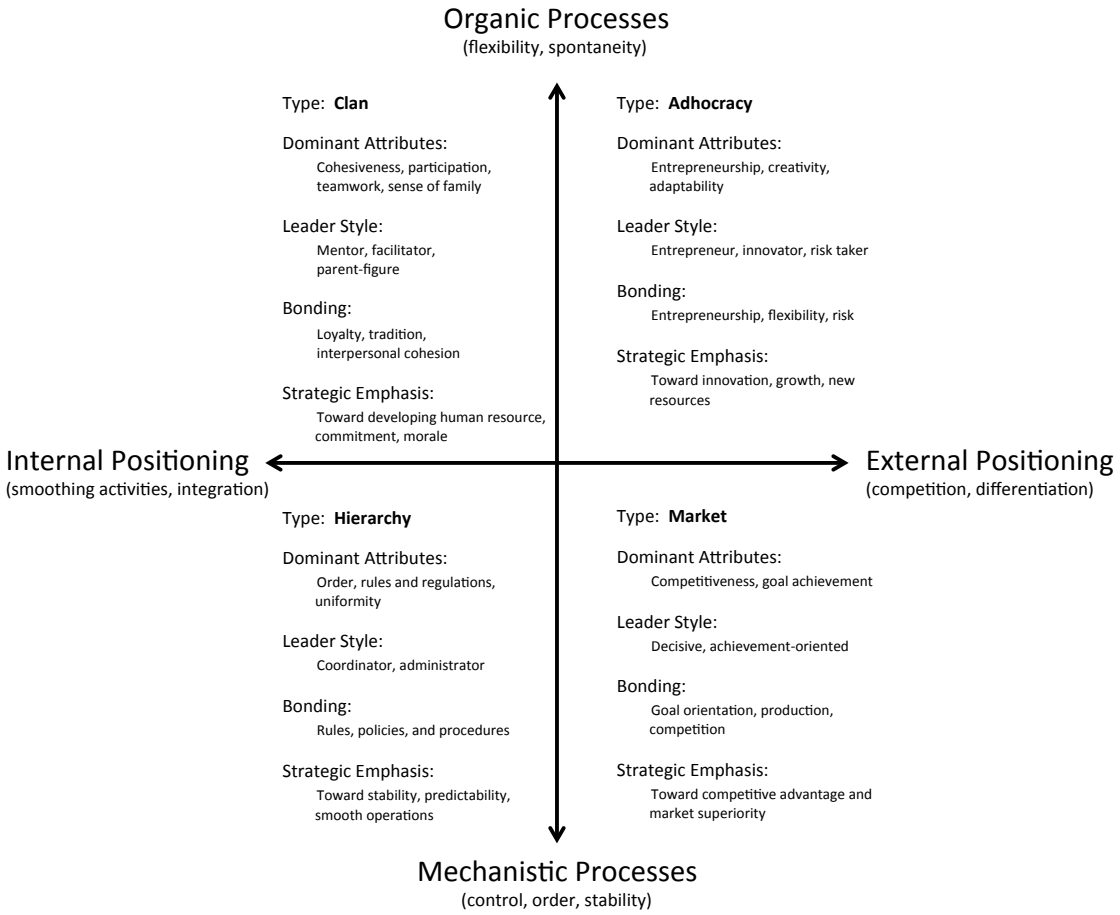
decades. Academics were intrigued by what they viewed as a shared set of beliefs and values that was dispersed throughout the organization. Often times this culture dictated how a firm viewed its' customers and its' core business functions (Deshpandé and Webster 1989). OC also exhibits variations from firm to firm (Reynolds 1986). In fact, scholars have argued that OC might dictate why some firms are more successful than others (Moorman 1995; Deshpandé, Farley and Webster 1993; Deshpandé and Webster 1989; Reynolds 1986).

Deshpandé et al. (1993) adopt the Competing Values Framework (CVF) to outline a categorization scheme for organizational culture. The CVF finds its earliest inception in the management domain through the works of Quinn (1988) and Quinn and Rohrbaugh (1983). The framework attempts to provide a categorization schema for various organizational cultures. The CVF has found empirical support in a number of marketing studies that study OC (White et al. 2003; Srinivasan et al. 2002; Berthon et al. 2001; Moorman 1995). The acceptance of the CVF is because organizational theorists view organization culture as broad and multi-faceted, and thus need to make sense of OC by grouping various cultural characteristics into types (Yarbrough et al. 2011).

Based on earlier work (Deshpandé and Webster 1989), Deshpandé et al. (1993) define a select number of cultures in a CVF, (see Figure 2-4) that attempts to capture the entire gamut of cultural facets linked to organizations. The four resulting types of culture are extrapolated based on two key dimensions: (i) internal versus external orientation and (ii) formal versus informal governance (Deshpandé et al. 1993). Related literature often times classifies the latter dimension as flexibility and discretion versus stability and control (Cameron and Quinn 1999).

As can be seen from Figure 4, Deshpandé et al.'s (1993) CVF posits four distinct types of culture. As mentioned previously, the primary distinction between them is based on how each type of culture differs along the dimensions of orientation and governance style. In addition, each has certain characteristics that make them distinct from the other types.

Figure 2-4 – Organizational Culture Types



(Adopted from Deshpande et al. 1993)

Adhocracy (also known as Creative) Culture is generally explained as one in which the firm adopts an external orientation while remaining flexible in terms of governance (or structure). As a result firms with this type of OC are often described as highly dynamic and entrepreneurial. Innovation and creativity are strongly encouraged by leaders, while risk-taking is embraced to gain any advantages that might result from it. A commitment to autonomy, acquiring new resources, and growth through change are what tend to unify the organization (Hartnell et al. 2011). In other words, firms with such cultures constantly strive to be on the leading edge and this explains the drive to be innovative through creative, adaptive, and risk-taking behaviors (Moorman 1995; Deshpandé et al. 1993).

Clan (also referred to as Collaborative) Culture maintains an emphasis on flexible governance while at the same time being internally oriented. Here, a focus on collaboration is evident in that such cultures tend to value affiliation, trust, loyalty and tradition, all of which symbolize the firm's internal orientation. As such, firms with a clan culture are often described as having open channels of communication, emphasizing teamwork, developing human resources and striving for higher levels of employee involvement and satisfaction (Hartnell et al. 2011; Deshpandé et al. 1993). Since importance is attached to consensus among employees with less emphasis on autonomy and creativity, there is generally less room for innovativeness and individual risk-taking behavior.

Hierarchy (or Control) Culture is characterized within the CVF as having formal structure combined with an internal orientation that results in a highly structured and formal place to work. As pointed out by Cameron and Quinn (1999), the overarching

theme is on stability through control. A premium is placed on values that reflect formalization, consistency, process and routines (Moorman 1995; Deshpandé et al. 1993). These characteristics highlight the formal governance structures usually employed by firms that adopt such a culture. Hierarchy cultures also seek out predictability in outcomes and as a result tend to be more risk averse in their choices.

Market (also known as Competitive) Culture is classified in the CVF as being focused on stability and control while being externally focused. This culture is characterized as striving for increased market share, productivity, growth, market superiority etc. through the process of achieving maximum competitiveness and customer focus (Hartnell et al. 2011; Deshpandé et al 1993). As a result, market cultures value information gathering, communication, wide ranging competence, planning and goal setting, and competition among other factors. As pointed out by Moorman (1995) such cultures are results driven and the there is a long-term emphasis on measurable goals and targets. Therefore, it can be argued that such cultures, while attempting to be innovative, will prefer known and predictable results. Hence, there is less incentive to deal with uncertain situations or outcomes.

It should be made clear however, that while the CVF posits a model of classifying various organizational cultures; these cultures are not mutually exclusive (Deshpandé et al. 1993; Cameron and Freeman 1991; Quinn 1988). Firms may exhibit multiple characteristics belonging to the various cultural types discussed above. For example, a firm with a clan culture may place emphasis on competitiveness and innovativeness, both facets that a clan culture is not associated with. In this regard, it is widely accepted that firms exhibit a dominant or modal culture that emerges over time and takes precedence

(Deshpandé et al. 1993).

It is clear that certain decisions are made under uncertain circumstances (see section 2.4.2. for a review of ambiguity aversion). This uncertainty could present itself as a characteristic of the outcome of the choices, or the availability of information to make a rational choice, or even in terms of the choices at hand. In this regard, it is relevant to point out that organizational theorists have suggested that OC plays an important role in how managers deal with ambiguity.

Moorman (1995, p. 320) points out that organizational culture can "affect, first, the firm's choice of outcomes and, second, the means to achieve these outcomes, including organizational structure and processes." In other words, Moorman's (1995) argument suggests that OC has a fundamental impact on the type of decisions that managers make; especially in terms of choosing between various outcome choices. Multiple academics have made similar claims (Cameron and Freeman 1991; Deshpandé et al. 1993; Hatch 1993; Quinn and Rohrbaugh 1983; Ruekert, Walker, and Roering 1985; Webster and Deshpandé 1990). For example, Cameron and Freeman (1991) suggest that managers should consider the role and importance of OC when faced with, and potentially dealing with, ambiguity.

Quinn (1988) points out that OC has a function in how managers choose among various outcome choices. Deshpandé et al. (1993) suggest that OC will have a greater impact on business performance especially under conditions of high uncertainty. In addition, organizational culture can factor into various managerial decisions relating to the means to achieve a desired outcome (Moorman 1995; Wilkins and Dyer 1988).

Ultimately, there is an abundance of scholarly research that points to some relationship between OC and how managers deal with ambiguity. This is often discussed in terms of how managers deal with strategic decision choices involving ambiguous outcomes or how they influence the structure and processes adopted by the firm in an indirect attempt to deal with ambiguity.

As outlined above, there is strong evidence to suggest that organizational culture does have an impact on how managers make decisions. These influences are heightened when managers are faced with ambiguity thus influencing their level of ambiguity aversion. In the next section, a literature review of innovation culture is provided.

2.3.2. Innovation Culture

A firm's organizational culture attains more significance when discussed in regards to innovation. As pointed out earlier, in today's dynamic and über-competitive business environments, innovation has been singled out as essential to a firm's ability to gain a competitive advantage (Quinn 2000; Prahalad and Hamel 1990). Academics have frequently suggested that an innovative culture is essential for any firm seeking to be a leader in innovation (Govindarajan and Trimble 2005; Hammer 2004; Christensen and Raynor 2003; Senge and Carstedt, 2001). Hurley and Hult (1998, p.44) have hinted that an innovation culture is a "measure of the organization's orientation toward innovation." Relatedly, Rubera and Kirca (2012) suggest that an innovation culture allows firms to be more productive with their resources when innovating.

Keeping in mind that organizational culture is a multi-faceted concept (as described in section 2.3.2.), Dobni (2008) conceived of a definition of innovation culture

as multi-dimensional in nature. This suggestion is influenced by the work of Damanpour (1991) and others. An innovation culture is not limited to a set of behaviors and activities (directly related to innovation) and is not simply about product- or process-innovation. It also encompasses aspects such as how project teams are organized, the role mangers play in innovation and their attitudes to change and uncertainty, a firm's intention to innovate and how that reflects on its strategy etc. (Damanpour 1991). However, Damanpour's (1991) conceptualization of innovation culture seems flawed in that the construct's definition is muddled with the construct's antecedents and outcomes.

In relation to this need to view innovation culture as multi-faceted, there has been extensive discussion about the role of market orientation on innovation (Narver, Slater and MacLachlan 2004; Lukas and Ferrell 2000; Han, Kim and Srivastava 1998; Hurley and Hult 1998; Kohli and Jaworski 1990). While Kohli and Jaworski (1990) view market orientation as comprising competitor orientation, customer orientation and inter-functional coordination, it is Narver and Slater's (1995) view on market orientation that applies better in the context of this dissertation. Market orientation is considered an organizational culture and is defined as "the culture that (1) places the highest priority on the profitable creation and maintenance of superior customer value while considering the interests of other key stakeholders; and (2) provides norms for behavior regarding the organizational development of and responsiveness to market information" (Narver and Slater 1995, p. 67). There is a strong consensus that a high level of market orientation significantly aids a firm's ability to be successful at innovation (Marinova 2004; Narver and Slater 1995; Kohli, Jaworski and Kumar 1993; Jaworski and Kohli 1993). Hence, scholars sometimes find parallels between innovation culture and market orientation.

Keeping this need for a broad conceptualization of innovation culture, Hurley and Hult (1998, p. 44) define innovation culture as "openness to new ideas as an aspect of firms' organizational culture." However, in an effort to provide a broader conceptualization of innovation culture in keeping with the arguments made above, Wang and Ahmed (2004, p. 304) define such an innovation culture as "an organization's overall innovative capability of introducing new products to the market, or opening up new markets, through combining strategic orientation with innovative behavior and process."

Expanding on Wang and Ahmed's definition, Dobni (2008, p. 540) defines innovation culture as "a multi-dimensional context which includes the intention to be innovative, the infrastructure to support innovation, operational level behaviors necessary to influence a market and value orientation, and the environment to implement innovation." Dobni's (2008, p. 543) conceptualization views innovation culture as ranging from the "intention to be innovative, to the capacity to introduce some new product, service or idea through to the introduction of processes and systems which can lead to enhanced business performance."

Both Wang and Ahmed (2004) and Dobni's (2008) definitions recognize the multi-dimensional conceptualization of innovation culture advocated in the extant literature. The conceptualizations focus not only on the straightforward behaviors and activities related to innovation, but also the underlying intentions, processes and strategy involved, including the importance of market orientation.

It is important to discuss how an innovative culture serves as an important antecedent to innovation in firms. The managerial behavior and decision making that

arises from innovation culture seem to impact (i) organizational structure (for e.g. a lesser emphasis on formal structure), (ii) the adopted firm-wide processes (such as stressing on teamwork, adaptability and flexibility), (iii) the emphasis placed on certain firm-wide values (like competitiveness, risk-taking, customer focus), and (iv) the ability to inculcate employees with values such as creativity, freedom, openness in communication etc. (Hurley and Hult 1998; Tesluk et al. 1997; Chatman and Jehn 1994).

To expand on some of the points made above, innovation culture plays an important role in how firms organize for innovation (Burns and Stalker 1966). Parallel comparisons can be drawn from Deshpandé et al.'s (1993) competing values framework (section 2.3.2.), which suggests that firms that have cultures that result in an informal (or organic) structure will tend to be more innovative and creative. Relatedly, Jassawalla and Sashittal (2003) point out that an innovative culture will hinder the possibility that a firm adopts a rigid or more formal structure. Hurley and Hult (1998) stress the importance of collaboration (via cross-functional teams), teamwork, and flexibility in aiding innovation in firms. Similarly, within the CVF, Deshpandé et al. (1993) suggest that firms characterized as having adopted informal governance tend to be more innovative.

Ultimately, it is widely accepted that in an innovation culture behaviors and values that highlight creativity, risk-taking, flexibility, spontaneity etc. are given higher priority (Hurley and Hult 1998; Chatman and Jehn 1994; Deshpandé et al. 1993; Burns and Stalker 1966). At the same time, in such a culture, behaviors and values that might be detrimental to innovation, including excessive control and rigidity, emphasis on tradition and stability, weighting predictability etc. would de-prioritized (Jassawalla and Sashittal 2003).

This dissertation adopts Hurley and Hult's (1998) definition of innovation culture – "openness to new ideas as an aspect of firms' organizational culture." While it can be argued that an innovation culture is imperative for any firm that attempts to attain a high level of performance in regards to innovation, these relationships have not been fully explored in terms of a project leader's strategic decision making in relation to innovation. A conceptual model that explains of how innovation culture impacts managerial decision-making is discussed in-depth in the next chapter.

2.4. Literature on Decision-Making and Judgment

This section details the literature on decision-making and judgment. Of particular interest is the Decision Theory approach to understanding how individuals deal with uncertainty. Specifically, I examine extant literature in both Economics and Psychology to gain a key understanding on managerial aversion to ambiguity. The review also contrasts ambiguity aversion to risk aversion. Key antecedents to ambiguity aversion are also discussed.

2.4.1. Ambiguity

Published research has attempted to examine various parameters that play a role in decision making. Among them, two in particular have attracted intense attraction among decision-making theorists - ambiguity and risk (Trautmann et al. 2008). Knight (1921) first suggested that there is a clear distinction between risk – a situation where uncertainty is bound by known probabilities and ambiguity – where uncertainty cannot be quantified. As pointed out by Muthukrishnan (1993, p. 4-5) "decision researchers use the terms uncertainty, ambiguity and vagueness to describe the state in which the relevant

probabilities of outcomes are unknown or cannot be ascertained with reasonable accuracy." Essentially there are two types of uncertainty, "measurable uncertainty or risk, which can be represented by precise probabilities, and unmeasurable uncertainty, which cannot," called ambiguity (Fox and Tversky 1995, p. 585).

Ambiguity has been defined as a "quality depending on the amount, type, reliability and unanimity of information" (Ellsberg 1961, p. 657). Einhorn and Hogarth (1985, p. 453, 455) while proposing that "ambiguity results from having limited knowledge of the process that generates outcomes," suggest that it "highlights the distinction between one's lack of knowledge of the process that generates outcomes and the uncertainty of outcomes *conditional* on some model of the process." Based on Einhorn and Hogarth's (1954) conceptualization, Muthukrishnan (1993, p. 5) defines ambiguity as the "uncertainty about uncertainty, where the latter 'uncertainty' refers to outcome probability." Ambiguity has also been conceptualized as "the subjective experience of missing information relevant to a prediction" (Frisch and Baron 1988, p. 152). Elaborating on Frisch and Baron (1988), Camerer and Weber (1992, p.330) define ambiguity as the "uncertainty about probability, created by missing information that is relevant and could be known." As is evident from the definitions mentioned hereto, ambiguity in the context of decision-making cannot be explicated without mention of the amount of information available. Ambiguous situations are those where "available information is scanty or obviously unreliable or highly conflicting; or where expectations of different individuals differ widely; or where expressed confidence in estimates tends to be low" (Ellsberg 1961, p. 660-61).

Table 2-3

SELECT DEFINITIONS OF *AMBIGUITY* FROM VARIOUS STREAMS OF LITERATURE

Author(s)	Stream	Definition
Knight (1921)	Economics	"measurable uncertainty, or "risk" proper, as we shall use the term, is so far different from an unmeasurable one that it is not in effect an uncertainty at all. We ... accordingly restrict the term "uncertainty" to cases of the non-quantitative type
Ellsberg (1961)	Economics	"quality depending on the amount, type, reliability and unanimity of information."
Einhorn and Hogarth (1985)	Psychology	"highlights the distinction between one's lack of knowledge of the process that generates outcomes and the uncertainty of outcomes conditional on some model of the process."
Hoch and Ha (1986)	Marketing	"the potential for multiple interpretations."
Frisch and Baron (1988)	Psychology	the subjective experience of missing information relevant to a prediction."
Kahn and Sarin (1988)	Marketing	"the second-order uncertainty, or in other words, the probability distribution of perceived probabilities."
Camerer and Weber (1992)	Economics	"uncertainty about probability, created by missing information that is relevant and could be known,"
Muthukrishnan (1993)	Marketing	"uncertainty about uncertainty, where the latter 'uncertainty' refers to outcome probability,"
Muthukrishnan (1995)	Marketing	"non-comparability among competing options in terms of the amount and type of decision-relevant information available."
Bleaney & Humphrey (2006)	Psychology	"ambiguity is relevant information that is either not known or not fully understood."
Lee and Suk (2010)	Marketing	"existing on a continuum ranging from novel at one extreme to highly familiar at the other."

Ellsberg (1961) found that people, when given a choice, are more likely to choose a riskier bet with known probabilities as opposed to a less risky one in which the probabilities are ambiguous. Ellsberg (1961) exhibited this phenomenon in a number of simple experiments, the most famous of which is widely referred to as the 'two-color'

problem. Given two urns each containing a hundred balls, a study participant is told that the first urn contains 50 red and 50 black balls and that the second urn contains red and black balls in an unknown proportion. Ellsberg (1961) demonstrated that when a participant is offered a reward depending on the outcome from randomly drawing the balls, participants (while indifferent on betting either red or black balls for either urn) were more likely to bet on the first urn (with the known composition) rather than the second urn (with the unknown composition). In other words, study participants exhibited a preference for gambles with known (risky) rather than unknown (ambiguous) probabilities of winning (Muthukrishnan et al. 2009; Ellsberg 1961).

As Ellsberg (1961) points out, his findings are inconsistent with the axioms of subjective expected utility theory (Savage 1954). Subjective expected utility theory is an extension of expected utility theory. Von Neumann and Morgenstern's (1947) expected utility theory deals with outcomes with known probabilities. Subjective expected utility theory, on the other hand, looks at outcomes with probabilities that are not objectively known (Savage 1954). In relation to Ellsberg's 'two-color' problem, subjective expected utility theory would predict that people are indifferent between urns (Camerer and Weber 1992; Ellsberg 1961). However in Ellsberg's 'two-color' problem, people show a clear preference for the urn with the known probabilities of red and black balls. As such Ellsberg's counter intuitive findings in relation to the established axioms of subjective expected utility theory have been referred to as Ellsberg's paradox (Muthukrishnan et al. 2010; Al-Najjar and Weinstein 2009; Bonanno et al. 2009; Trautmann et al. 2008; Fox and Tversky 1995; Camerer and Weber 1992).

2.4.2. Ambiguity Aversion

The phenomenon exhibited in Ellsberg's paradox has become known as ambiguity aversion (Muthukrishnan et al. 2010; Trautmann et al. 2008; Fox and Tversky 1995; Camerer and Weber 1992; Heath and Tversky 1991). Fox and Weber (1992) suggest that ambiguity aversion is basically an unwillingness to bet on probabilities that are vague in nature. In a similar manner, Heath and Tversky (1991, p.11) suggest that ambiguity aversion "implies that people will prefer to bet on a chance event whose probability is well defined rather than on their judged probability, which is inevitably vague" in nature. Trautmann et al. (2008, p.225) define ambiguity aversion as situations where people "prefer options involving clear probabilities (risk) to options involving vague probabilities (ambiguity)."

It is clear from the various definitions provided here that ambiguity aversion, a view this dissertation adopts, is a situation encountered in decision making. However it should be noted that there are those that suggest that the phenomenon of ambiguity is meaningless in a decision-making context (de Finetti 1977). Regardless, as Camerer and Weber (1992, p.329) point out, such viewpoints "do not help explain descriptive evidence of ambiguity aversion."

How individuals deal with ambiguity aversion has received much attention in the literature. Specifically, there have been multiple, descriptive models offered to explain judgments under ambiguity (Al-Najjar and Weinstein 2009; Camerer and Weber 1992; Einhorn and Hogarth 1985).

Table 2-4

SELECT DEFINITIONS OF *AMBIGUITY AVERSION* FROM VARIOUS STREAMS OF LITERATURE

Author(s)	Stream	Definition
Ellsberg (1961)	Economics	When given a choice, individuals are more likely to choose a riskier bet with known probabilities as opposed to a less risky one in which the probabilities are ambiguous - *paraphrased*
Hofstede and Bond (1984)	Psychology	"The extent to which people feel threatened by ambiguous situations, and have created beliefs and institutions that try to avoid these"
Schmeidler (1989)	Economics	"A decision maker is Uncertainty Averse if, for each pair of acts *f* and *g*, *f* indifferent to *g* implies that every convex combination of *f* and *g* is preferred to *f* (and to *g*)."
Gilboa et al. (1989)	Economics	"A decision maker is strictly Uncertainty Averse if she prefers any convex combination of every two non-comonotonic acts *f* and *g*, between which she is indifferent, to *f* and *g*."
Heath and Tversky (1991)	Psychology	"implies that people will prefer to bet on a chance event whose probability is well defined rather than on their judged probability, which is inevitably vague."
Fox and Weber (1992)	Psychology	"an unwillingness to bet on probabilities that are vague in nature."
Trautmann et al. (2008)	Economics	"prefer(ance for) options involving clear probabilities (risk) to options involving vague probabilities (ambiguity)."

For example, Einhorn and Hogarth (1985) employ an anchoring and adjustment framework to explain probability assessments. Einhorn and Hogarth (1985) postulate a model where individuals, when faced with ambiguity, make adjustments to initial estimates of ambiguity (the anchor) using mental simulations. Within their framework, the adjustment is based on "(a) the amount of ambiguity, which affects the size of the simulation, and (b) one's attitude toward ambiguity, which affects the differential weighting" of the anchor (Einhorn and Hogarth 1985, p. 433).

An alternative model proposed by Fox and Tversky (1995) suggests that decisions that involve uncertainty depend not only on the degree of uncertainty but also its source. In this regard, Fox and Tversky (1995) put forth the comparative ignorance hypothesis according to which ambiguity aversion is driven by contrast or comparison effects – comparing to more familiar events or with more knowledgeable individuals. They go on to suggest that ambiguity aversion is more or less absent without an avenue for such comparisons to occur.

Fox and Weber (2002) extend the work on the comparative ignorance hypothesis by outlining various decision contexts that can influence an individual's willingness to make a decision under uncertainty. They point out that "(1) any feature of the decision context that makes a contrasting state of knowledge more salient should exacerbate ambiguity aversion; and (2) the absolute degree of ambiguity aversion exhibited depends on the decision maker's relative knowledge concerning the contrasting states that are available" (Fox and Weber 2002, p. 492). Such attributes of the decision contexts include situations where uncertain bets are preceded by questions about less familiar items, or when diagnostic information about the bet that is indiscernible is provided to the individual.

Ambiguity aversion has also been modeled as a situation arising from the perception of missing information (Frisch and Baron 1988). Frisch and Baron (1988) attempt to address whether ambiguity effects are rational, and go on to suggest that how individuals perceive missing information relevant to a probability judgment is crucial to the subjective experience of ambiguity aversion.

There are multiple academics that discount the role of ambiguity aversion as described in the various descriptive models above (Nehring 2009; Al-Najjar and Weinstein 2009; Heath and Tversky 1991). One model of ambiguity aversion views it as a semi-rational response to ambiguity. Nehring (2009, p.332) suggests "ambiguity-averse behavior results from projecting robustness onto the plane of choice consistency/preference maximization." So in another words, decisions under ambiguity aim to achieve robustness rather than avoid the inherent ambiguity. Here robustness in decision making is described as when one "avoids one-sidedness and arbitrariness, if it integrates multiple viewpoints and gives all viewpoints "their due" (Nehring 2009, p. 314). The underlying theme to Nehring's (2009) work, is that robustness, is the rational response to ambiguity not aversion.

Heath and Tversky (1991) suggest that ambiguity aversion has a minor role in decision making under uncertainty. They offer the competence hypothesis that suggests that individuals would prefer betting based on their own personal judgments rather than an equally probable chance event. In other words, a decision maker is more likely to prefer betting on an ambiguous ability-based event rather than unambiguous chance-based event (Klien et al. 2010). This is especially the case when he/she perceives a high degree of competence over the decision domain (Heath and Tversky 1991).

An illustrated example is useful to put the competence hypothesis in context. An average football fan is more likely to bet on the outcome of a football game rather than an unambiguous chance event with the same outcome probability than an average non-fan. Even though the outcome of the football game is *a priori* ambiguous, the football fan could possibly feel highly competent in regards to his knowledge of the game, the teams

involved, and other related attributes. Therefore instead of exhibiting ambiguity aversion and choosing the unambiguous chance event of equal probability, the fan's perceived competence over the decision domain attenuates his/her ambiguity aversion.

The competence hypothesis as described suggests important differences in decision making under choice. Heath and Tversky (1991) employ a broad conceptualization of competence. It includes the notion of skills, knowledge, and/or understanding of the given decision context. However, it should be noted that the perceived competence should be in the domain of the decision context and the resulting outcome. As such, this conceptualization of competence is highly state dependent.

There are related constructs to perceived competence that have been widely employed in the marketing and management literature. Self-efficacy is chief among them. Bandura (1986, p. 391) defined perceived self-efficacy as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances." Bandura (1986) clearly points out that self-efficacy is focused on one's judgments of what he/she can do with the skills they possess rather than a mere concern for what skills are possessed. It is also suggested that self-efficacy is especially important in "prospective situations that contain many ambiguous, unpredictable, and often stressful elements" (Bandura 1981).

Work on social cognitive theory that deals with self-efficacy often discusses competence. Within social cognitive theory, competence is often described in terms of the skills one possesses, and how they are organized and integrated (Bandura 1981). Clearly, competence and self-efficacy share certain similarities. However, as pointed out

earlier, self-efficacy has more to do with an individual's judgments on how their skills can be effectively utilized in a given situation. On the other hand competence can be thought of as more of a stock of skills in one's possession.

In relation to the competence hypothesis, Heath and Tversky (1991) clearly refer to a decision-makers competence in regards to their knowledge, skills and understanding given a decision domain. Not their judgments on how they can utilize their skills, knowledge, and understanding. Therefore there is a clear distinction between the perceived competence construct and self-efficacy construct in relation to the competence hypothesis. As such, I define perceived competence as an individual's sense of skill, knowledge and understanding over a given decision context.

Heath and Tversky (1991) point out that an individual's sense of competence over the decision context plays a dominant role on an individual's sense of ambiguity aversion. As a conjecture, Heath and Tversky (1991) point to the asymmetric assignment of credit and blame in their interpretation of their findings on competence hypothesis. They suggest, "the balance of credit to blame is most favorable for bets in one's area of expertise, intermediate for chance events, and least favorable for bets in an area where one has limited knowledge" (Heath and Tversky 1991, p. 8). In other words, competent individuals take the credit for winning bets while incompetent individuals receive blame for losing bets (Heath and Tversky 1991; Camerer and Weber 1992).

Al-Najjar and Weinstein (2009) provide a critical review of the ambiguity aversion literature and provide some insight that again questions the efficacy of the ambiguity aversion construct. The authors contend that viewing aversion to ambiguity as

being a rational behavior is equivalent to admitting that other choices like aversion to information or sensitivity to irrelevant sunk costs are rational too. This, in their opinion is too much to accept for most economists. Al-Najjar and Weinstein (2009) also add that the "seemingly anomalous behavior" seen in the Ellsberg paradox can be explained "using standard tools of information economics and game theory" (p. 251).

While this dissertation only looks at a few descriptive models that attempt to explain aversion to ambiguity. Interested readers should refer to Camerer and Weber (1992) for an in depth review of formal models that tackle ambiguity aversion.

2.4.3. Psychological Traits and other Causes of Ambiguity Aversion

A lot of focus has gone into understanding why individuals, when faced with situations such as Ellsberg's "two color" problem, exhibit an aversion to ambiguity. Psychologists look at the causes of ambiguity aversion in a different manner compared to decision theorists and economists.

Curley, Yates and Abrams (1986) provided a psychological insight into the antecedents of ambiguity aversion. Their work focused on various previous explanations of the antecedents of ambiguity aversion, and they set out to test a number of these proposed antecedents. While they tested six total explanations, Curley et al. (1986) found one psychological source of ambiguity aversion in particular affected subjects' judgments under situations deemed ambiguous. They found that ambiguity aversion "appears to result from an anticipation by decision makers that their decisions will be evaluated by others," (p. 253). Hence subjects "make the choice perceived to be most justifiable to others" (p.230, as a result they make the safer choice/decision.) Curley et al. (1986)

termed this effect other-evaluation. Their study is also relevant in that they rule out other antecedents of ambiguity aversion such as fear of hostile outcome determination process, anticipation of future self-evaluation, and interestingly the "general avoidance of uncertainty of the type described by risk-aversion measures," (p.253).

More recently, academics have tended to refer to what Curley et al. (1986) call "other-evaluation," as fear of negative evaluations (FNE, Trautmann et al. 2008). FNE is defined as the "apprehension and distress arising from concerns about being judged disparagingly or hostilely by others" (Carleton et al. 2006, p. 297). Similarly, Fox and Tversky (1998) and others suggest that an anticipated evaluation by others has a relevant effect on ambiguity aversion (*cf*. Trautmann et al. 2008; Fox and Weber 2002). Adding more credence to FNE as a source of aversion to ambiguity, Trautmann et al. (2008) found evidence which suggests that aversion to ambiguity can be eliminated if FNE among study subjects is removed. This possibly suggests that ambiguity aversion can show up only as long as there is FNE involved. If "preferences between outcomes are private information, so that others cannot judge the goodness of decisions and outcomes" ambiguity aversion may not arise at all (Trautmann et al 2008).

Others have also supported the FNE argument as a psychological source of ambiguity aversion (Fox and Weber 2002; Fox and Tversky 1998; Heath and Tversky 1991). In line with the competence hypothesis, ambiguity aversion gets enhanced when an individual perceives others as being more competent or knowledgeable. This can be related to a situation, where an individual chooses an ambiguous option that ends in a negative outcome, thereby subjecting the individual to potential criticism by others (more

knowledgeable or competent). Such evaluations by others, especially negative criticisms, are avoided when making risky choices as bad outcomes can be attributed to bad luck.

Academics have also looked into how differences in perceived informational content prior to the outcome process can impact ambiguity aversion. For example Chow and Sarin (2002) show that individuals tend to shy away from ambiguous choices especially when an alternative route to decision making, laden with more information, is available. This effect also appears when others have access to the information while the individual choosing between ambiguous and risky choices does not have the information at hand. However, ambiguity aversion is reduced or becomes more 'tolerable' when it is clear that others also lack the information that could lead to a better decision (Chow and Sarin 2002).

As discussed previously, Frisch and Baron (1988) make a similar claim suggesting that ambiguity aversion is increased when the perception of missing information is high. Chow and Sarin (2002) suggest that their findings are consistent with Fox and Tversky's (1995) comparative ignorance hypothesis by suggesting that comparative ignorance effects are weaker when 'relevant' information is not available. One can also draw parallels between Chow and Sarin's (2002) findings, and those explicated from the competence hypothesis, where one's perceived competency in the decision making process can impact aversion to ambiguity.

Source effects can also impact ambiguity aversion. Taylor (2000, p.118) suggests that "the source from which ambiguity arises affects attitudes indirectly by altering the set of psychological variables that enter into a consumers' decision making." Essentially,

the author submits that when the source of ambiguity is internal (i.e. self-generated by the individual) then the individual's level of knowledge and confidence will drive aversion to ambiguity. So if an individual is extremely knowledgeable about the situation at hand, they are likely to be less ambiguity averse because they have confidence in their internal approximations of the probability of uncertainty. On the other hand if the source of ambiguity is external (for e.g. provided by a third party) Taylor (2000) suggests that an individuals attitude toward risk, both in terms of the decision and the resultant outcome, will play a significant role in ambiguity averse behavior. The overall results suggest that internally generated sources of ambiguity tend to lower ambiguity aversion.

Scholars have had success explaining differences in attitudes towards risk in the domain of losses and gains (Prospect Theory; Kahneman and Tversky 1979). In light of this, there has been work that has attempted to explain variations in attitude towards ambiguity using the same perspective. Extant studies in the area fail to explain variations in ambiguity aversion using framing that replicates gain and loss domains (Kahn and Meyer 1991; Kahn and Sarin 1988). However, it has to be noted that these studies have found that the presence of ambiguity accentuates attitudes toward risk. In other words, in the presence of ambiguity, individuals will seek out clearer probabilities.

2.4.4. Ambiguity versus Risk

It ought to be pointed out that research attempting to better understand uncertainty, has often been drawn to risk rather than ambiguity. As a consequence, much of the underlying debate surrounding ambiguity has risen from work undertaken to

comprehend the phenomenon of risk. (*cf.* Einhorn and Hogarth 1985; Ellsberg 1969; Knight 1921).

Risk and models attempting to explain it have received wider acceptance in the literature, much more so than ambiguity aversion and its accompanying models. This can be attributed to the veracity and simplicity with which risk aversion models explain the phenomenon of risky choice behavior (Einhorn and Hogarth 1985). However as pointed out by Ellsberg (1961) an explanation of risk is incomplete without properly examining ambiguity. Einhorn and Hogarth (1985, p. 458) follow in a similar vein when suggesting "although the importance of ambiguity for understanding risk has been evident since Ellsberg's original article, its omission from the voluminous literature on risk is puzzling." The following paragraphs discuss the definition of risk, models that explain it, and how extant research has delineated ambiguity from the phenomenon of risk.

Unlike ambiguity, risk has enjoyed a more clearly defined status in the literature. Most researchers base their definitions of risk on Knight's (1921) viewpoint (Pushkarskaya et al. 2010; Holton 2004; Ellsberg 1961). Knight (1921, p. 233) proposed that "between the measurable uncertainty and an unmeasurable one we may use the term "risk" to designate the former and the term "uncertainty" for the latter." Additionally, Knight (1921) suggested the term "objective probability" could be used to describe risk. The overall manner in which 'Knightian' risk is conceptualized arises from Knight's deep-rooted philosophical view of phenomena as being objectively observable and therefore quantifiable.

Table 2-5

DISTINGUISHING BETWEEN RISK AND UNCERTAINTY/AMBIGUITY

Author(s)	Risk	Uncertainty and/or Ambiguity
Knight (1921)	Measurable uncertainty	Unmeasurable uncertainty
Knight (1921)	Objective probabilities	Subjective probabilities
von Neumann and Morgenstern (1947)	Known outcome, known probabilities	Known outcome, unknown probabilities
Ellsberg (1961)	Represented via numerical probabilities	Cannot be represented via numerical probabilities
Einhorn and Hogarth (1985)	Utilities and probabilities are not independent	Assumption of non independence between utilities and probabilities cannot be assumed
Kahn and Sarin (1988)	Presence of ambiguity accentuates attitude towards risk	No evidence to show risk accentuates sense of ambiguity
Camerer and Weber (1992)	Modeled using both Expected and Subjective Expected Utility Theory	Modeled using Subjective Expected Utility Theory but treats high levels of ambiguity as risk

A simple way to understand Knightian risk would be to view it as constituting known outcomes with known probabilities (von Neumann and Morgenstern 1947). Ellsberg (1961, p. 643) concurs with Knight (1921) and von Neumann and Morgenstern (1947) while suggesting that risk "may be represented by numerical probabilities." Table 5 below further outlines some of the lines along which various authors have distinguished between risk and uncertainty and/or ambiguity.

As can be seen from Table 5, there is a lot of common ground among decision theorists in regards to risk. This commonality can be directly attributed to the reliance on viewing risk from Knight's perspective. This has in turn led to the use of similar models

to explain the phenomenon. Foremost among these models is Expected Utility theory and, later, Subjective Expected Utility theory.

Expected Utility (EU) was formalized by von Neumann and Morgenstern (1947) and is generally applied to situations represented as gambles or lotteries. Within EU, a lottery (X) is defined as a set of outcomes, $x_i \ldots x_n$. Each of the possible outcomes has an associated probability, $p_i \ldots p_n$. Based on this notation, the theory suggests that the expected utility of a lottery is

$$EU(x) = \sum_{i=1}^{n} p_i u(x_i) .$$

The risk phenomenon is captured in the utility function *u( )* that essentially accounts for the preference for a particular outcome. EU theory assumes that the probabilities of outcomes are known in advance, and requires individual preferences to adhere to three axioms (complete ordering, continuity, and independence) in order for the utility index to account for risk.

However, since outcome probabilities are rarely known *a priori*, Savage (1954) proposed Subjective Expected Utility (SEU) theory as a work around to EU's strict requirement for probabilities that are objectively known. As a result, "SEU applies more widely than EU" (Camerer and Weber 1992, p. 325). While the formulaic representation of SEU is similar to EU, there are some differences that ought to be pointed out. SEU accounts for difference in the state of nature (state, for short) that could impact the consequences associated with a choice or preference. Since these states do not have objective probabilities associated with them, individuals have to make subjective probability inferences on the states. Therefore "preferences over acts reveal both a utility

function over acts and a set of personal or subjective probabilities over states" (Weber and Camerer 1987, p. 130). So using the notation outlined above for EU, the SEU of an act or choice X is

$$SEU(x) = \sum_{i=1, s \in S}^{n} p(s)u(x_i(s)).$$

Here a state is represented as s and p represents the probability associated with the state.

However, there is growing concern in the field of decision theory that traditional models that espouse Knight's viewpoint fail to account for important psychological factors that may be at work (Johnson 2004; Camerer and Weber 1992). The argument is centered on the view that, while EU and SEU are good normative models to explain decisions involving risk, they lack descriptive ability (Johnson 2004).

While Knight's (1921) conceptualization forms the most popular basis for defining and modeling risk, there are yet others who have approached the phenomenon from differing angles based on the reasons stated above. For example, Holton (2004, p. 22) defines risk as "exposure to a proposition of which one is uncertain." Holton's (2004) outlook on risk differs from that of Knight's (1921) and other behavioral economists in that he adopts a more general viewpoint, applicable to a wide variety of situations and not bound to measurement, probabilistic inferences or the widely used subjective expected utility theory. Holton (2004) also clearly suggests that risk is a phenomenon that is encountered by entities that are self-aware, such as humans, and as such is only experienced in organizations through the human aspect.

Other attempts at modeling risk have been driven by what many consider the apparent failure to account for important psychological factors that might influence decision making. Prospect theory (Kahneman & Tversky 1979) has gained wide traction as a viable alternative to the EU and SEU paradigm. Prospect theory shares part of its foundation with EU in that it also treats outcomes as having probabilities. However in prospect theory, where probabilities are not considered weights, a separate weighting function is employed (Kahneman & Tversky 1979). This, in addition to relaxing some of the assumptions of EU and SEU, have allowed prospect theory to obtain (in some cases) greater descriptive validity when explain decision choices involving risk.

Scholars have also attempted to explain risky decisions employing heuristic models. For example Brandstätter, Gigerenzer & Hertwig (2006) put forth the priority heuristic where decision choices among risky options are made employing heuristics based on a set of priorities that a decision maker might have. In the case of the priority heuristic, these priorities refer to high or low priority information. Employing the priority heuristic, an individual can ignore or discount pieces of information requiring less cognitive resources and thus hasten the decision process.

There are other models that attempt to explain decision behavior involving risk, such as those based on rank dependence. Nevertheless, Knight's (1921) conceptualization of risk and the EU/SEU schools have dominated the literature in explaining risk. However, while this may be sufficient to explain risk, as discussed previously in the dissertation, these models fail to adequately explain ambiguity.

2.4.5. Ambiguity Aversion versus Risk Aversion

Similar to the discussion between ambiguity and risk, ambiguity aversion and risk aversion differ, often widely, in terms of their definition, explanatory models, and accompanying phenomenon. Rather than looking into a domain-specific risk aversion construct, in this dissertation I compare a general view of risk aversion to ambiguity aversion.

It is necessary to provide a brief overview of these two, often conflicting yet related, schools of thought dealing with risk aversion. Scholars have long argued whether or not individuals experience risk aversion regardless of the situation, circumstance, domain etc. (Matzler, Grabner-Kräuter and Sonja 2008; Mandrik and Bao 2005). In other words do people exhibit a general aversion to all types of risk be it financial, social, and performance-related amongst others. Weber and Milliman (1997) suggest that risk aversion should be examined as a domain specific construct. Even though it is argued that a general cross-situational type of risk aversion is likely, its detection could be diluted by a multitude of context specific variables (Weber and Milliman 1997). Such variables include the probability of negative outcomes, the likelihood of one's choice being assessed or judged after the choice and outcome are made clear, and the general uncertainty involving possible number of outcomes. As pointed out by Matzler et al. (2008, p. 155) such issues can "be alleviated when risk aversion is examined as domain-specific construct."

Even within the consumer behavior domain, risk aversion is often viewed as a context specific variable. For example in brand management and related literature, the

suggestion that brands can reduce perceived risk (Erdem and Swait 1998; Montgomery and Wernerfelt 1992), follows from the underlying view that risk aversion is a domain specific phenomenon. A similar predisposition towards a domain specific risk aversion construct can be seen in other consumer behavior streams such as information search (e.g. Moorthy, Ratchford, and Talukdar 1997; Gemünden1985; Moore and Lehmann 1980) and product choice (e.g. Rao and Bergen 1992; Tellis and Gaeth 1990; Shimp and Bearden 1982) to outline a few.

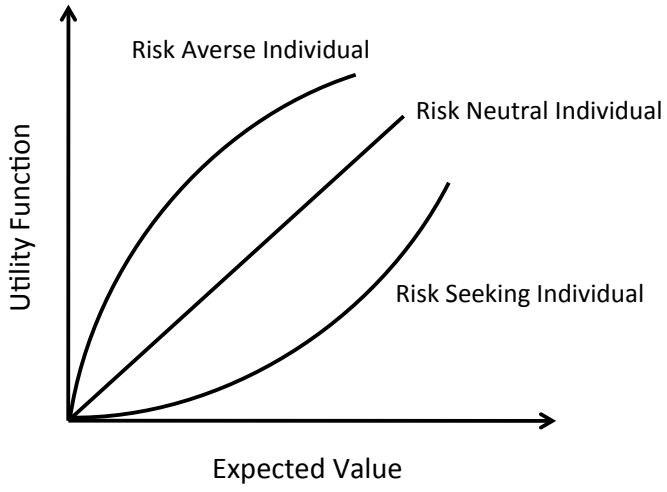
On the other hand, there are many who advocate a 'general risk aversion' construct. One that is cross-situational in nature (Mandrik and Bao 2005; Xiao et al. 2001). This type of risk aversion would manifest as a trait that exhibits across any type of situation that might involve a risky choice. Some scholars refer to this as a baseline level of risk aversion and conceptualize it as a 'general aversion to risk, regardless of domain,' (Mandrik and Bao 2005). This broader conceptualization of risk aversion has received just as much scholarly attention as the more domain specific variant especially in the fields of economics and finance (Xiao et al. 2001). This dissertation adopts this general viewpoint on risk aversion, rather than a more domain specific variant. Over the next few pages, a history of risk aversion, various measurement approaches and a clear definition of 'general' risk aversion are discussed.

Peoples' propensity to make risky decisions has been the focus of scholarly inquiry for a considerable period of time. A majority of the early work can be found in the discipline of Economics followed by Psychology. Early inferences into the risk aversion phenomenon arose out of work performed by behavioral decision theorists looking into risky choice behavior (cf. Kahneman and Tversky 1979). As such, the

phenomenon was mostly applied to study various economic applications especially under the paradigm of EU theory.

As mentioned earlier in the discussion on EU theory, risk is modeled as a utility function, "*u( )*" If the function exhibits as a concave curve, an individual is described as being risk averse; and if the functions is shown as being convex, then an individual is described as being risk seeking. Keeping this in mind, a risk neutral individual would exhibit a linear utility function (Fischer et al. 1986; Miller 1975). The scholarly dialog on EU makes it apparent that risk aversion is essentially an individual's attitude towards risk. This can be reasoned based on how it is often treated as a difference variable between individuals within the EU paradigm (Qualls and Puto 1989). While adopting the interpretation of risk aversion as an attitude, EU theory subsumes that it is constant across multiple domains (cf. Mandrik and Bao 2005; Qualls and Puto 1989). In other words, EU theory suggests that risk aversion is not a domain specific construct as discussed earlier, rather a cross-situational construct.

Figure 2-5 - The Graphical Representation of Risk Aversion



So in adopting the general risk aversion viewpoint, this dissertation finds it imperative to discuss and ultimately select an appropriate definition for the construct. In keeping with the voluminous academic work focused on risk aversion, many have put forth definitions (both scientific and not) in an effort to appropriately capture the construct. Table 2-6 below outlines a number of risk aversion definitions that have gained traction in the associated literature.

Table 2-6

SELECT DEFINITIONS OF *RISK AVERSION* FROM VARIOUS STREAMS OF LITERATURE

Author(s)	Stream	Definition
Kahneman and Tversky (1979)	Economics	"A person is risk averse if he prefers the certain prospect (x) to any risky prospect with expected value x"
Montesano (1988, 1986)	Economics	"the difference between the expected value of the action under consideration and its certainty equivalent"
Chew et al. (1987) and Yaari (1987)*	Economics	"a decreasing preference for an increasing risk"
Qualls and Puto (1989)	Marketing	a decision maker' s "preference for a guaranteed outcome over a probabilistic one having an equal expected value"
Weber and Milliman (1997)	Management	"a person's preference for alternatives perceived as less risky"
Mandrik and Bao (2005)	Marketing	an individual's "degree of negative attitude toward risk arising from outcome uncertainty"

* cf. Montesano (1990)

As mentioned previously, this dissertation defines ambiguity aversion as the "preference for options involving clear probabilities to options involving vague probabilities" (Trautmann et al. 2008). When compared to the definitions of risk aversion provided in Table 6 above, there are a number of factors that clearly distinguish the two constructs. First, it is clear that risk aversion captures attitudes on options or

choices that are linked to clearly defined probabilities. Ambiguity aversion however captures an individual's attitude towards those options, outcomes or decision choices where the associated probabilities are unknown or vague. While this distinguishing factor has been pointed out previously, there are instances where risk aversion is associated to uncertainty. For example Mandrik and Bao (2005) argue that it is important to capture uncertainty as a component of risk aversion, and as a result their definition reflects this stance. While the extant literature seemingly favors risk aversion in studies related to decision-making and choice behavior, one can easily ascertain that real world choices or outcomes rarely present with clearly established probabilities and hence it is imperative to distinguish between the two constructs.

Second, the definitions outlined in Table 6, and others that attempt to capture the cross-situational risk aversion construct, overtly rely on EU theory to form an accurate conceptualization of the construct. This manifests itself in definitions that depend on comparing an individual's predisposition towards prospects that share the same outcome value be it certain or expected. On the other hand, since ambiguity aversion is not strongly bound to EU, we do not see definitions that are too reliant on comparing outcome values.

Finally, as mentioned earlier, there are two schools of thought in regards to risk aversion; the domain specific point of view and the cross-situational or generalized viewpoint. This has resulted in a myriad of construct definitions for risk aversion that reflect these interpretations. While there is still area for further conceptual refinement in regards to the ambiguity aversion construct; it is however not afflicted by extremely divergent perspectives like risk aversion. Therefore, the various definitions of ambiguity

aversion (many of which have been discussed earlier) present a common underlying theme.

In spite of the fundamental differences between the definitions of risk aversion and ambiguity aversion, there is an important commonality. Both constructs attempt to capture the negative valence associated with the phenomenon of uncertainty. Keep in mind that individuals that exhibit risk or ambiguity aversion are inclined to avoid risky/ambiguous situations. As such the construct definitions adopted by this dissertation for both risk aversion and ambiguity aversion adequately capture the negativity associated with the concepts.

2.5. Summary

Chapter II has reviewed three, considerably distinct, streams of literature; innovation, organizational culture, and ambiguity aversion. Throughout the chapter, I have attempted to draw connections between the three. Through the review, it is clear that innovation culture and innovation show a strong relationship to each other. On the other hand the review on ambiguity and ambiguity aversion might appear more incongruent in connection to innovation and culture. Nevertheless, it is key to remember that there is high degree of uncertainty inherent in the front-end of innovation, thereby leading to situations where managers might face decisions with ambiguous outcomes.

As pointed out during the review of the literature on innovation, the front-end stages of innovation are likely to include decisions involving ambiguity rather than risk. One way to view the various stages of innovation is that considerable effort is expended on risk-reduction. That is to say, the innovation/new product development process

converts amorphous ideas into tangible products that have a maximum chance of success in the commercial marketplace. However, this may lead to a preference for advancing product concepts where risk, in terms of clear probabilities, can be more easily established. At the same time, those new ideas and product concepts that are ambiguous may be discarded or screened out simply because it seems difficult to discover the probability estimates.

Since published literature suggests that there are clear differences between ambiguity and risk, in terms of their antecedents and outcomes, it is of theoretical and practical import to study them in the context of innovation. As mentioned previously, this is especially relevant in terms of decisions made at the front-end of innovation which generally involve a lot of ambiguity. My contribution is to improve our understanding of innovation by studying ambiguity aversion in a decision-making context.

Chapter III will attempt to make this connection and posit a conceptual model that will define the relationships between a project leader's ambiguity aversion and its impact on innovation. Table 2-7 (below) outlines the key constructs in this dissertation and provides their definitions.

Table 2-7

KEY CONSTRUCTS AND DEFINITIONS

Construct	Citation	Definition
Ambiguity Aversion	Trautmann et al. (2008)	Preference for options involving clear probabilities to options involving vague probabilities
Fear of Negative Evaluation	Carleton et al. (2006)	Apprehension and distress arising from concerns about being judged disparagingly or hostilely by others
Perceived Competence	Heath and Tversky (1991) - *adapted*	An individual's sense of skill, knowledge and understanding over a given decision context
Decision Making Comprehensiveness	Slotegraaf and Atuahene-Gima (2012)	Degree to which the team is exhaustive as it considers multiple approaches, courses of action, and decision criteria in its strategic decision making
Innovation Culture	Hurley and Hult (1998)	Openness to new ideas as an aspect of firms' organizational culture
Capacity to Innovate	Hurley and Hult (1998)	Ability of the organization to adopt or implement new ideas, processes, or products successfully
Front-End of Innovation Performance	Mohan (This Dissertation)	An overall evaluation of the quality of the product concepts produced by the front-end of innovation process.

CHAPTER III

CONCEPTUAL MODEL AND RESEARCH HYPOTHESES

3.1. Introduction

The current chapter is organized into three main sections. The chapter begins with an overview and general discussion of the proposed conceptual model. Here I present the model in Figure 3-1 and briefly outline the proposed relationships. The conceptual model is based on an extensive review of the literature. Chapter II discusses this review of the literature and has identified several areas that show promise in terms of serving as potential avenues for further research. As such the first section ties some of the research gaps while presenting the conceptual model.

While ambiguity and innovation were discussed in Chapter II, the second section of this chapter goes further to establish the relationship between the two. Here the manuscript debates the various sources and subjects of ambiguity in innovation.

This is intended to assist the reader in drawing connections between the seemingly disparate domains. In addition, this section is vital in providing further credence to the relationships that are proposed in the conceptual model. The third section is divided into multiple subsections that provide an in depth examination of the SEVEN hypotheses that the conceptual model postulates. Each relationship within the model is examined in greater detail, while I provide the theoretical justifications for each testable hypothesis. The chapter concludes with a brief summary.

3.2. The Research Context

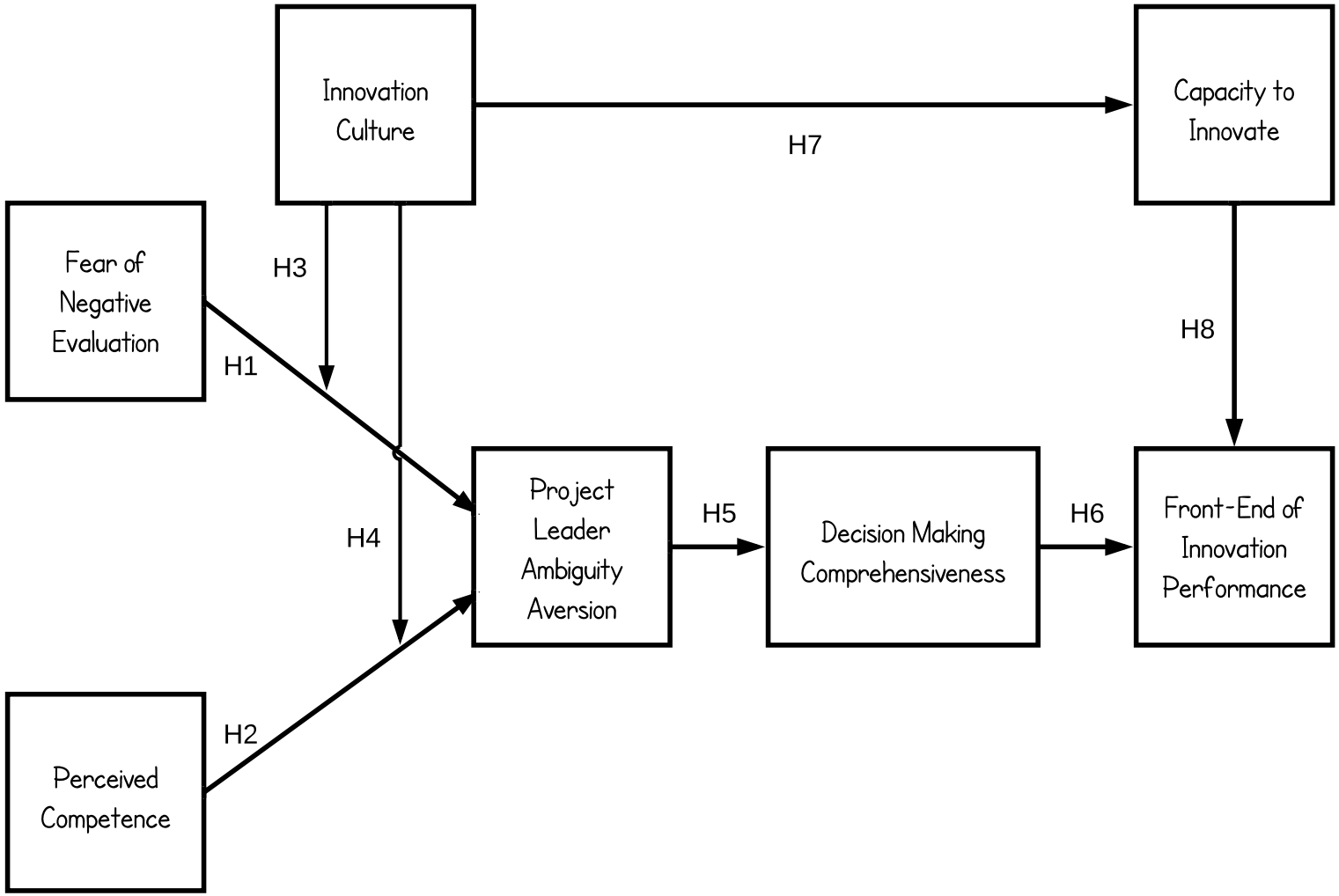
As previously outlined in Chapter II, innovation is key to firm success. More and more firms are diverting their attention to understand how they can be better at innovation (Hauser, Tellis and Griffin 2006). The front-end of innovation has often been singled out as an area where firms could potentially make improvements that could theoretically result in better innovation performance (Cooper 2001). Improvement is thought possible because the front-end of innovation is ambiguity laden (see sections 2.3. and 3.3. for a detail discussion). In other words, the front-end of innovation, sometimes described as being fuzzy, involves decision choices and situations that are ambiguous in nature. One potential area for gains is to understand the extensiveness and impact of ambiguity aversion among project leaders. To the extent that front-end decisions filter out ideas or options based on ambiguity, the new product development process may miss opportunities, focus on the wrong projects, or even cancel new product ideas/concepts that could potentially be very successful for the firm.

The focus of this dissertation is to propose and test a model that explains and

predicts the impact of project leaders' ambiguity aversion on innovation performance, and how that in turn affects firm performance. The conceptual model in Figure 3-1 draws on two antecedents of ambiguity aversion suggested by the literature reviewed in Chapter II: 1) fear of negative evaluation and 2) the project leader's sense of competence over the decision context. Fear of negative evaluation is expected to have a positive relationship with ambiguity aversion such that when FNE is high (low), ambiguity aversion is also high (low). The relationship between sense of competence and ambiguity aversion, however, is negative. When the project leader's sense of competence is high (low), ambiguity aversion will be low (high).

Importantly, the proposed model considers the role of the firm's innovation culture in moderating the relationships between fear of negative evaluation and ambiguity aversion as well as between sense of competence and ambiguity aversion. These moderated relationships have not been explored so far in either the ambiguity or innovation literature. As detailed further below, I contend that when innovation culture is weak, ambiguity aversion will be high because individuals operating within such organizational cultures do not embrace uncertainty. On the other hand, I suggest that in firms with strong innovation cultures the distinction between risk and ambiguity is of fundamental importance, and individuals will be motivated to convert ambiguity into risk. Thus, in the conceptualization I present below in firms with strong innovation cultures FNE is positively related to ambiguity aversion while sense of competence is negatively related to ambiguity aversion. Ambiguity aversion then leads to a mediated chain of constructs which culminates in firm performance. These relationships are developed and discussed below.

Figure 3-1 – The Conceptual Model



3.3. Ambiguity in Innovation

The innovation process can be divided into three parts: the front-end, new-product development, and commercialization. While there has been no lack of research activity focused on new-product development (see Brown and Eisenhardt 1995 and Montoya-Weiss and Calantone 1994), little attention has been focused on the front-end.

As discussed in the previous chapter, innovation, especially at the front-end, is shrouded in uncertainty. Brun, Saetre and Gjelsvik (2009) have previously attempted to classify the types of ambiguity faced in new-product development. Their conceptualization of ambiguity shares commonalities to how I have previously defined ambiguity. Brun et al. (2009, p. 66) define ambiguity as "the existence of two or more interpretations of a single cue." To remind the reader, this dissertation adopts a simplified version of Muthukrishnan's (1993) definition of ambiguity, the uncertainty about outcome probability. While at face value the conceptualizations seem unrelated, upon further inspection, it becomes clear that Brun et al. (2009) when discussing ambiguity are essentially referring to a lack of clarity about outcome probability. Therefore, their work classifying the types of ambiguity in the new-product development process has direct application to the conceptual model presented in this dissertation.

Brun et al.'s (2009) main findings suggest that ambiguity in the innovation process can be thought of in terms of two dimensions: the sources of ambiguity and subjects of ambiguity. While the subjects of ambiguity refer to *what* the key participants in the innovation process experience ambiguity *about*, the sources refer to the underlying cause of the ambiguity. The three key sources of ambiguity include multiplicity of the

subject, novelty of the subject, and the validity and reliability of available information (Brun et al. 2009). While the first two sources are directly related to the subjects of ambiguity, the third is concerned with quality of relevant information.

Collecting reliable and valid information is one important way to eliminate ambiguity during the new product development process. Validity concerns how appropriate the available information is to the innovation. Reliability deals with the consistency of that information. Since ambiguity aversion is defined herein as the "preference for options involving clear probabilities to options involving vague probabilities," the reliability and validity of gathered information lays the foundation for fixing the needed probabilities in the mind of the respective project leader(s).

However, it is difficult for firms to have prior knowledge or information regarding whether a new product concept/idea will succeed or not. Reliable and valid information about the future is not available to the project team or its leader. Therefore, as mentioned earlier, we often describe decisions made at the front-end of innovation as fuzzy, directly related to the ambiguity surrounding the decisions choices available to the project leader and other key participants. To put it succinctly, I view the new product development process as a path in which probabilities of new product success/failure are made clear and in which the success probabilities are maximized while the failure probabilities are minimized.

To the extent project leaders are ambiguity averse, the inherent ambiguity in the front-end of innovation might bias the screening decision toward ideas for which the probabilities seem clearer or easily obtainable and away from ideas which appear to be

more challenging in terms of fleshing out the probabilities. As a result, it is common to see promising projects cancelled while surer ideas (that are often incremental advances) proceed through the innovation process (Cooper 2001, Hauser, Tellis and Griffin 2006; Brun et al. 2009). This could be detrimental to the long-term success of the firm and it its overall competitiveness in the marketplace. Therefore, it becomes essential to understand, explain, and predict ambiguity aversion so that it can be managed and overcome in the new product development process.

3.4. Research Hypotheses

The following subsections detail and discuss each of the relationships presented in the conceptual model (see Figure 3-1). I also provide the reasoning behind the proposed relationships. Each subsection ends with a clear statement of the testable hypothesis for each relationship discussed.

3.4.1. Fear of Negative Evaluation and Ambiguity Aversion

This dissertation defines fear of negative evaluation as the "apprehension and distress arising from concerns about being judged disparagingly or hostilely by others" (Carleton et al. 2006, p. 297). As evidenced in the work of Trautmann et al. (2008) and others (Curley et al. 1986; Fox and Tversky 1998), FNE has been shown to have a significant impact on an individual's ambiguity aversion. This effect is described in terms of the perceptions an individual has of how others evaluate his/her decision. If there is a possibility of a negative outcome as a result of the choice or decision made by the project leader, then he/she may subject to negative evaluations if co-workers become aware of the situation. When making decisions that involve clear probabilities (i.e. risk),

decision makers can more easily explain and defend their decision. However, when probabilities are vague it becomes harder to show that the decision was justified and, hence, counter the negative evaluations that follow (Fox and Weber 2002; Trautmann et al 2008). Therefore, in the face of ambiguity, individuals exhibit higher ambiguity aversion when there is a high FNE.

In an organizational context, employees experience FNE. Fear serves as a powerful motivating force, and in an organization individuals may be mindful of scrutiny from superiors, competing colleagues, and even from those that work under the individual. Since employees are continually motivated to remain and advance at their jobs, FNE can become important in the context of decision making. Since ambiguous choices more difficult to defend than decisions with known probabilities, individuals with high FNE will be reluctant to engage in behavior involving unknown chances.

This is true of the innovation process as well. As mentioned earlier, project leaders often face a high level of ambiguity in the front-end of innovation. This leads to situations where they exhibit ambiguity aversion. For example, if there were clear probabilities associated with the outcome of a product concept, and a project leader chose to continue development on that particular concept, even if it fails the project leader can counter any negative evaluation based on his/her approach to risk-taking. Such individuals will naturally prefer ideas and concepts that appear more concrete and for which the future looks more certain. Thus, ideas and concepts that are amorphous, opaque, and lack clarity may be more readily eliminated from consideration, despite strong underlying merit. Therefore, FNE tends to drive ambiguity aversion among project leaders. As a result:

H1: *When fear of negative evaluation is high, the project leader experiences a significantly higher level of ambiguity aversion compared to when fear of negative evaluation is low.*

3.4.2. Perceived Competence and Ambiguity Aversion

Recall from Chapter II that Heath and Tversky (1991) have suggested that an individual's response to ambiguity is driven by perceived competence. In regards to this, Heath and Tversky (1991, p. 7) state that an individual's "willingness to bet on an uncertain event depends not only on the estimated likelihood of that event and the precision of that estimate; it also depends on one's general knowledge or understanding of the relevant context."

The competence hypothesis is an important concept that helps explain decision-making— especially in the face of uncertainty (Heath and Tversky 1991). The underlying explanations of the competence hypothesis can be attributed to "both cognitive and motivational" processes (Heath and Tversky 1991, p. 7). For example, we frequently feel more comfortable making choices (betting) on chance events (like the outcome of a football game) if we feel more knowledgeable and competent over the decision context (like the strength and records of the two teams that are playing).

This phenomenon becomes all the more apparent in a firm setting. Just like FNE, perceived competence can prove to be a strong motivating influence. An individual, say a project leader, may feel like they have specific areas of expertise wherein they feel confident. This sense of competence over the decision scenario might be a result of past experiences, the development of skills that apply closely to the situation, or having access

to knowledge bases deemed important to the decision scenario. This perceived self-competence should facilitate decision making even if that probabilities involved are vague, cloudy, and not clearly understood. On the other hand, when perceived competence is low, a project leader would favor choices for which the odds seem well known but would be unwilling to deal with ambiguous choices, thereby leading to a high level of ambiguity aversion.

Looking at this from an innovation viewpoint, where there are often multiple sources of ambiguity, it is common to see project leaders and key participants in the innovation process lean toward projects that they are comfortable with and feel competent to manage (Hauser, Tellis, and Griffin 2006). While at the same time, certain projects and ideas may be rejected because of a project leader's lack of perceived competence (*cf.* Hauser, Tellis, and Griffin 2006; Cooper 2001; Damanpour 1991)

In other words, an individual's stance with respect to ambiguity is dependent on the individual's own self-judgment of their competence. Here, perceived competence encompasses an individual's personal skills, knowledge, understanding, and judgments. So when faced with a context in he/she feels competent or knowledgeable an individual would be more willing to embrace ambiguous outcomes. Conversely, if an individual perceives low competence, i.e. he/she feels uniformed, ignorant, or unprepared over the decision context, then it is likely that they would avoid the ambiguous choice.

H2: *A project leader's perceived competence over the decision domain is significantly related to his/her level of ambiguity aversion, such that when perceived competence is high, ambiguity aversion is low and vice versa.*

3.4.3. The Moderating Role of Innovation Culture

While both FNE and perceived competence have been shown to have an important bearing on individual decision-making under uncertainty, their impact can be made to dissipate under various moderating conditions. In an organizational context, I argue that one such moderating condition is a firm's innovation culture.

This dissertation adopts Hurley and Hult's (1998) definition of innovation culture. They define it as the "openness to new ideas as an aspect of firms' organizational culture" (Hurley and Hult 1998, p. 44). This definition appropriately captures the aspects of a firm's culture that place an emphasis on values, and beliefs focused on innovation. In addition to keeping with Deshpandé, Farley, and Webster's (1993) definition of organizational culture in regards to shared values and beliefs, the current definition also provides understanding and norms for behavior within the firm.

As discussed in Chapter II, innovation culture is an important antecedent to innovation performance in firms. As a culture, it can have an important effect on key participants in the innovation process, including project leaders. This is especially the case since innovation culture provides a guide or norm for behavior that assists project leaders in their decision-making roles. To remind the reader, an innovation culture places a premium on beliefs and behaviors that stress creativity, risk-taking, flexibility, spontaneity etc. At the same time such a culture helps to avoid actions and decisions that might be harmful to the overall innovative performance of the firm.

In this dissertation I attempt to study in greater depth the impact of innovation culture on a project leader's decision making especially in terms of ambiguity aversion. Since an innovation culture is expected to have an impact on employee behavior, it could potentially impact employee decision-making. Therefore, it becomes an area of further investigation in the current context. So far, I have pointed out two key antecedents to ambiguity aversion, FNE and perceived competence. Below I conceptualize how innovation culture can serve a moderating role between ambiguity aversion and its antecedents.

I have previously proposed a main effect of FNE on ambiguity aversion which posits a positive relationship. However, I argue that this relationship would change based on the strength of a firm's innovation culture. When firms have a strong innovation culture in place, the impact of FNE on a project leader's ambiguity aversion will exhibit a strong positive relationship. On the other hand, when innovation culture is weak, a project leader would exhibit ambiguity aversion regardless of his/her extent of FNE.

The conceptual reasoning behind this theorizing is simple. While a strong innovation culture will add weight to the reduction of ambiguity aversion when FNE is low, it does not have the necessary power to influence individuals that have a high degree of FNE. This is attributable to the fact that fear, a deeply rooted emotion, holds considerably more motivational power than an organization's culture (in this case innovation culture). Therefore, it is difficult to suggest that, no matter how strong an innovation culture, it would have no bearing on a project leader's ambiguity aversion when he/she experiences high FNE.

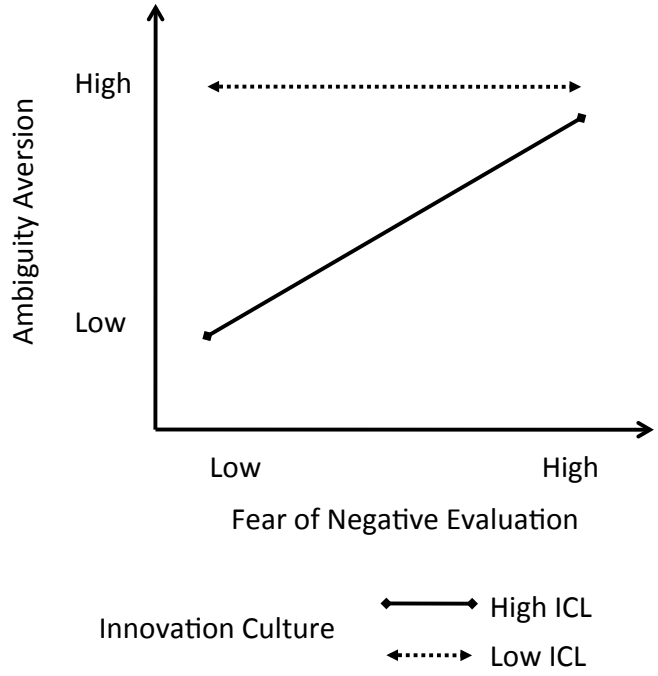
The relationship between FNE and ambiguity aversion is more interesting in the presence of a weak innovation culture. Most would expect that in firms with weak or no innovation culture, a project leader with low FNE would exhibit little ambiguity aversion. After all, that is what the direct effect suggests. On the contrary, I suggest that under a weak innovation culture, a project leader with low FNE would exhibit a higher level of ambiguity aversion. In other words, regardless of whether a project leader experiences high or low FNE, he/she would always show high aversion to ambiguity.

This counter intuitive relationship can be justified on the premise that a project leader, low on FNE, has no incentive to embrace uncertainty (be it risk or ambiguity). The incentive to embrace ambiguous outcomes comes from having an innovation culture. Since an innovation culture is lacking or weak here, one could argue that the firm and its culture are opposed to choices involving ambiguous outcomes since there is no emphasis on risk-taking and other related pursuits. Hence, a project leader has no motivation to be anything but ambiguity averse.

In other words, one could say that an innovation culture, by its own nature, discriminates against uncertainty. This means that firms with a weaker innovation culture will hold values and beliefs that are less receptive to uncertainty. Such an innovation culture, being organization wide, would permeate into how the organization's employees react and deal with uncertainty. Therefore a firm characterized as having a weak innovation culture, would espouse values and beliefs that are apprehensive to ambiguity and risk. Thereby resulting in a situation where, a project leader for example, even if low on FNE, would be high on ambiguity aversion since he/she reflects an organizational culture that is uncertainty averse. As a result:

H3: *When innovation culture is weak, there is no clear relationship between fear of negative evaluation and ambiguity aversion (although ambiguity aversion should be high), on the other hand when innovation culture is strong, there is strong positive relationship between fear of negative evaluation and ambiguity aversion.*

Figure 3-2 - Interaction of Fear of Negative Evaluation and Innovation Culture



Innovation culture can also have important moderating effects on the relationship between a project leader's perceived competence and his/her level of ambiguity aversion. Previously I proposed a negative main effect between perceived competence and ambiguity aversion. This relationship would remain intact in situations when a firm has a strong innovation culture. However in the presence of a weak innovation culture, or a lack of it, I contend that a project leader would exhibit high ambiguity aversion regardless of his/her perceived competence over the decision context

As pointed out in the previous chapter, Heath and Tversky (1991) have suggested that competence hypothesis effects can be attributed to the asymmetric attribution of credit and blame. When applied to a strong innovation culture, a decision maker with a high degree of perceived competence is more likely to receive credit for bets associated with gains. At the same time, if the choice results in a loss, such an individuals could potentially protect themselves from blame by justifying their decision choice on their competence or expertise. On the other hand, as pointed out by Heath and Tversky (1991, p. 8), "incompetence or ignorance prevents people from taking credit for success and exposes them to blame in case of failure." Therefore, a decision maker with low competence has a limited chance of receiving credit for gains associated with risk taking while concurrently exposing himself to heavy blame and criticism if the decision choice involves losses.

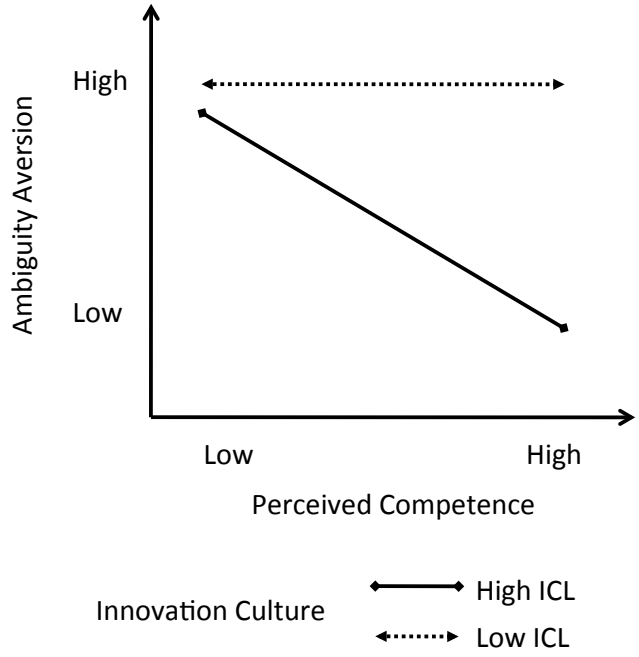
This can be explained based on the values espoused by a strong innovation culture. As pointed out earlier, a strong innovation culture emphasizes risk taking values and the gains arising from such pursuits. In such a culture, a decision maker high on competence has much to gain and little to lose. If they make winning bets (choices) the associated credit is all theirs, while at the same time blame arising from losses can be shielded by justifying the decision choice on competence or expertise. Therefore, such a decision maker could potentially apply his knowledge and skills to convert unknown probabilities into known probabilities. That is, they can apply their expertise and knowledge of the decision domain to convert uncertainty (specifically ambiguity) into risk. As a result, a decision maker with high perceived competence in a strong innovation culture is likely to be low on ambiguity aversion.

On the other hand, in a similar culture, a decision maker low on perceived competence has a lot to lose and little to gain. That is, if the decision choice results in a loss, the decision maker will be subject to blame and cannot shield himself using the competence argument. Similarly, credit for any gains arising from the decision maker's choice would be directed elsewhere since the decision maker's competence had nothing to do with the decision. In addition, in a strong innovation culture, a decision maker who perceives low competence in a decision domain related to uncertainty, including risk, would not be able to convert unknown probabilities into risk with confidence (or might not have the skill or ability to do so). Therefore, a decision maker with low perceived competence in a strong innovation culture is likely to be high on ambiguity aversion.

I suggest that the relationship between perceived competence and ambiguity aversion is attenuated in a weak innovation culture. In such a culture, it is likely that blame for losses on a risky choice far outweigh the credit if the same choice resulted in gains. This can be attributed to the nature of weak innovation cultures as being contemptible to risk taking values. Such cultures stay away from risky choices at all cost. Any decision maker who makes a risky choice is likely to face sanctions regardless of the outcome. A decision maker (with high perceived competence) cannot protect himself from blame by justifying his decision based on competence or expertise. At the same time there could potentially be no assignment of credit since the firm does not value risk taking. In other words, it shouldn't matter how competent a decision maker perceives himself to be, there is no incentive to choose a risky option, let alone an ambiguous option.

Additionally, it is likely that a manager in a weak innovation culture will only perceive competence if they make decisions that are highly certain. In other words, taking decisions that are perceived as highly uncertain (as measured by risk or ambiguity) is prima facie evidence of incompetence in a weak innovation culture.

Figure 3-3 - Interaction of Perceived Competence and Innovation Culture



Hence, in a weak innovation culture, the level of perceived competence has no bearing on ambiguity aversion and should remain high throughout. This is again attributable to the all-encompassing nature of a firm's culture (in this case the innovation culture). Since a weak innovation culture would be guarded when faced with uncertainty, the employees of the firm would fall in line with the values, norms and beliefs that make it illogical for them to opt for uncertainty regardless of their level of perceived competence. Based on this I propose the following hypothesis:

H4: *When innovation culture is weak, there is no clear relationship between sense of competence and ambiguity aversion (although ambiguity aversion should be high). On the other hand when innovation culture is strong, there is a strong negative relationship between sense of competence and ambiguity aversion.*

3.4.4. Ambiguity Aversion on Decision-Making Comprehensiveness

Decision-making comprehensiveness was defined in the previous chapter as the "degree to which the team is exhaustive as it considers multiple approaches, courses of action, and decision criteria in its strategic decision making" (Slotegraaf and Atuahene-Gima 2011, p. 97). Their research suggests that it is an important team activity that has important implications on innovation activities and new product advantage, with antecedents including project team stability, project rewards, and task conflict (Slotegraaf and Atuahene-Gima 2011; Atuahene-Gima and Li 2004). Some have suggested that the project leader might have an impact on decision-making comprehensiveness within firms (Menon et al. 1999; Scott and Bruce 1994). This dissertation suggests that a project leader's ambiguity aversion serves as an important antecedent to the decision-making comprehensiveness of new product teams.

I conceptualize that there exists a negative relationship between a project leader's ambiguity aversion and the project team's decision-making comprehensiveness. In other words, when a project leader exhibits a high level of ambiguity aversion, the project team will show low levels of decision-making comprehensiveness, and vice versa.

This proposed relationship is again opposite to what many would expect. Normal convention would suggest that an ambiguity averse manager would potentially seek to remove the source of ambiguity by pushing his project team to seek further information

in order to obtain clear probabilities. However, this may not be the case. Project teams may be well aware of their project leader's tendencies in regards to dealing with choices that have ambiguous outcomes. As a result, when key team participants pick up on their leader's aversion to ambiguity, they are likely to prematurely expunge product concepts or ideas that they know have vague probabilities associated with their eventual outcome. If, on the other hand, the team is accustomed to a project leader whom they know is not ambiguity averse, they are likely to be far more comprehensive in their decision-making. This would be the case since there is a higher likelihood that the project leader would consider concepts and ideas without clear probabilities. Therefore they have an incentive to be more comprehensive in their decision making in an effort to convert any ambiguity into known risk.

The conceptualization presented here is based on cognitive miser theory. The theory derives from work done in social psychology, especially social cognition (Macrae, Milne, and Bodenhausen 1994; Fiske and Taylor 1984; Nisbett and Ross 1980). As pointed out by Moss and DiCaccavo (2005, p.512), the cognitive miser theory is an "influential model of schema function," used by individuals as a heuristic to reduce cognitive load. In the current context, the part of cognitive miser theory that is of conceptual use is the theory's take on individual's use of cognitive shortcuts; suggesting that individuals use various cognitive shortcuts in order to lower information-processing load (required for decisions). Knowing a manager is averse to ambiguity, team members can reduce their information-processing load not exhausting their limited cognitive resources on gathering and discovering information associated with new ideas and concepts that are not likely to gain their project leader's approval. This would serve as an

example of a cognitive shortcut within the cognitive miser theory approach. So given the theoretical justification and preceding conceptualization we have:

H5: *The relationship between ambiguity aversion and decision-making comprehensiveness is negative.*

3.4.5. Decision-Making Comprehensiveness on Front-End of Innovation Performance

Previous research has drawn empirical conclusions on the relationship between decision-making comprehensiveness and firm performance (Atuahene-Gima 2004; Menon et al. 1999). This positive relationship has also been extrapolated and evidenced in research looking at new product advantage and firm innovation performance (Slotegraaf and Atuahene-Gima 2011). The current manuscript, keeps with tradition in suggesting a positive influence of decision-making comprehensiveness on firm innovative performance.

However, rather than focus directly on overall firm innovation performance I focus specifically on the positive effect of decision-making comprehensiveness on front-end of innovation performance. As pointed out previously, the front-end of innovation involves numerous activities that require extensive research, collaborative work, and evaluating and justifying various outcome options. Consequently, it is imperative that in order to be successful at the front end of innovation, there has to be a high degree of decision-making comprehensiveness. If project teams lacked this key activity, there could possibly be various systemic failures at the front-end which would inevitably be passed on to the subsequent stages of innovation. As a result:

H6: *The relationship between decision-making comprehensiveness and front-end of innovation performance is positive.*

3.4.6. Innovation Culture on Capacity to Innovate

As a variable, capacity to innovate was first studied by Burns and Stalker (1961). This was succeeded by a multitude of scholars, each pointing to the important relationship between capacity to innovate and firm performance (Hurley and Hult 1998; Hult 1998; Porter 1990). Capacity to innovate is defined as the "ability of the organization to adopt or implement new ideas, processes, or products successfully" (Hurley and Hult 1998, p. 44).

As discussed previously, a firm's innovation culture provides the social capital that is imperative to any business looking to innovate. But the values and norms that characterize an innovation culture, even though widespread throughout the organization, do not directly impact firm performance. In fact, what does take place is a firm's innovation culture interacts with other structural processes to impact overall performance. The construct called 'innovative capacity' captures this phenomenon.

So, a firm that values innovation and develops norms that encourage behaviors which support innovation and or sanction behaviors that interfere with innovation will be highly likely to build skills and abilities that enable innovation. In other words, an innovative culture directly impacts a firm's innovative capacity

H7: *The relationship between Innovation Culture and Capacity to Innovate is positive.*

3.4.7. Capacity to Innovate on Front-End of Innovation Performance

This relationship has found wide spread empirical support (Hult, Hurley and Knight 2004; Hurley and Hult 1998). As such, I offer the following hypothesis which suggests that there exists a significant positive relationship between innovation culture and capacity to innovate. A strong innovative culture leads to an enhanced capacity to innovate (see discussion above, Hurley and Hult 1998). Within firms, innovative capacity refers to a firm's ability to adopt new ideas, processes, and/or innovations in a successful manner. Without the underlying culture and the resultant capabilities, there is nothing to suggest that firm performance will increase simply by pushing out new products. Therefore, extant research is in agreement that firm performance increases as a result of innovative capacity (Hult, Hurley and Knight 2004; Hurley and Hult 1998; Hult 1998; Porter 1990).

Similarly, scholars have reinforced the positive link between innovative capacity and specifically innovation performance (Slotegraaf and Atuahene-Gima 2011; Woodside 2005; Atuahene-Gima 2004; Carrilat, Jaramillo, and Locander 2004). However, there has been limited attention paid to the role of innovative capacity on the front-end of innovation performance. As pointed out by Hurley and Hult (1998) while drawing comparisons with Rogers (1983), innovative capacity serves an important role throughout all the stages of the innovation process (front-end, new-product development and commercialization).

It can be reasoned that since capacity to innovate entails a firm level capability to adopt new ideas, products, etc., it has a direct bearing on the front-end of innovation

performance. To remind the reader, front-end of innovation entails activities like idea generation, concept definition, and project and strategy implementation to name a few. These are all activities and skills that stand to benefit from a higher capacity to innovate. This suggests that there exists a positive relationship between innovative capacity and front-end of innovation performance. This specific relationship (rather than the link between capacity to innovate and firm performance as well as overall innovation performance) has not yet been adequately explored. Therefore:

H8: *The relationship between Capacity to Innovate and Front-End of Innovation Performance is positive.*

3.5. Summary

The front-end of the innovation process is an area in which uncertainty, and in particular ambiguity, is rife. The conceptual model proposed in this chapter views ambiguity aversion on the part of the new product project leader as detrimental to the overall success of the front-end of innovation process. Ambiguity aversion is potentially harmful because, conceptually, it is a threat to decision-making comprehensiveness. In essence, the usual decision-making rigor of the process may be short-circuited if meritorious ideas are rejected prior to the conduct of due diligence. Importantly, the conceptual reasoning of the proposed model suggests that this effect may have its greatest effect in organizations with strongly innovative cultures.

This chapter has provided a detailed look at the conceptual model. The relationships that have been identified in the conceptual model are based on the literature review provided in Chapter II. The current chapter has also expanded on the, heretofore,

underexplored connection between the ambiguity literature and innovation literature. The chapter also proposed multiple testable hypothesis (see Table 2-8 below) and the theoretical justifications underlying the relationships presented in the conceptual model. The next chapter will provide the reader the research design and methodology and the will be employed to test the proposed hypothesis.

Table 3-1

PROPOSED HYPOTHESES

Hypothesis	Statement
H1	When fear of negative evaluation is high, the project leader experiences a significantly higher level of ambiguity aversion compared to when fear of negative evaluation is low.
H2	A project leader's perceived competence over the decision domain is significantly related to his/her level of ambiguity aversion, such that when perceived competence is high, ambiguity aversion is low and vice versa.
H3	When innovation culture is weak, there is no clear relationship between fear of negative evaluation and ambiguity aversion (although ambiguity aversion should be high), on the other hand when innovation culture is strong, there is strong positive relationship between fear of negative evaluation and ambiguity aversion.
H4	When innovation culture is weak, there is no clear relationship between sense of competence and ambiguity aversion (although ambiguity aversion should be high. On the other hand when innovation culture is strong, there is a strong negative relationship between sense of competence and ambiguity aversion
H5	The relationship between ambiguity aversion and decision making comprehensiveness is negative.
H6	The relationship between decision making comprehensiveness and front-end of innovation performance is positive
H7	The relationship between Innovation Culture and Capacity to Innovate is positive
H8	The relationship between Capacity to Innovate and Front-End of Innovation Performance is positive

CHAPTER IV

RESEARCH DESIGN AND METHODOLOGY

4.1. Introduction

This chapter is organized into three major sections. The first section discusses the research design employed in this dissertation. This includes an overview of the population, sample frame, the survey approach, and information on key respondents and how I intend to tackle non-response bias.

The second section describes those aspects related to measurement. This section provides a detailed look at the key variables that are employed, including the dependent measure, predictor, moderating, and control variables. The psychometric properties of these measures are also discussed.

The final section provides a brief outlook on the data analysis plan employed in this dissertation. Here, justifications for using the adopted approach are also discussed, in addition to the procedures employed, how the hypotheses were tested, and an assessment of the psychometric properties of the data set.

4.2. Research Design

This section provides a detailed discussion of the research design employed in this dissertation.

4.2.1. Unit of Analysis

The key unit of analysis adopted within this dissertation is the individual decision maker. For example, the constructs fear of negative evaluation, sense of competence, and ambiguity aversion all are defined and measured at the individual level. These individual level constructs are placed within the organization by the innovation culture moderating variable. Finally, the three individual level constructs are connected to organizational processes and outcomes by their relationship to decision-making comprehensiveness and the performance of the front-end of innovation across multiple new product development projects. Since the goal was to study a decision maker's level of ambiguity aversion across multiple situations, this unit of analysis structure is apt. Second, since decision-making comprehensiveness is a key mediating variable in this dissertation and is defined in terms of multiple new product development projects, it would be inappropriate to employ a unit of analysis focused on a specific project.

4.2.2. Sample Frame

This dissertation attempts to study the ambiguity aversion of decision makers and its impact on front-end of innovation performance. This applies to a wide variety of contexts across a wide variety of industries. Therefore, the sampling frame employed in

this dissertation would ideally tap into the total population of decision makers involved in an innovation context.

However there was no convenient manner in which such a sampling frame can be constructed. That being said, this dissertation makes every attempt to employ a sample frame that is representative of the total population described above. In an effort to reach the appropriate key respondents, I employ the assistance of an online research panel. Research panels have had a long history of use in marketing research. This can be mainly attributed to the ease with which a researcher can collect data while easily gaining access to the appropriate sample frame. Online research panels are witnessing more widespread adoption in premier marketing journal (e.g. Arora, Henderson and Liu 2011; Danaher et al. 2011; Shachar et al. 2011).

Nevertheless, there are some methodological issues related to online research panels that ought to be discussed. For example, a primary issue of concern was the use of non-probability samples. However, (as pointed out by the AAPOR report) this only becomes a major problem when results are being used to make inferences about the total population. In this dissertation, we try to make inferences about theory, so we need not worry about it. Schillewaert and Emulemeester (2005) also report that data quality is not significantly impacted because of the non-probability sample used by online research panel companies.

Another issue of concern was related to a number of biases that could creep into online research panels. These include for example practiced bias, where respondents might be exposed to many surveys resulting in a higher likelihood of developing insider

knowledge. This could lead to a situation where respondents may be able to discern the overall research agenda and start reacting more like trained respondents. The AAPOR report also voices concerns about coverage and non-response errors. However, as discussed later, non-response and coverage issues can be easily tested for. Ultimately, the pros associated with the use of an online research panel outweigh the cons, especially since many of the disadvantages can be accounted or controlled for.

4.2.3. Survey Approach

To collect data, this dissertation adopts the survey approach. Survey research is an important method, or set of procedures, that help researchers collect information. The innovation literature is characterized by its use the survey approach as a dominant research method. For example, studies that have measured some of the constructs in this dissertation have all employed the survey approach (Slotegraaf and Atuahene-Gima 2011; Copper 2001; Hurley and Hult 1998; Deshpandé, Farley, and Webster 1993).

There are various types of information that researcher can collect via the use of survey method. Dillman (1978) suggests the following types of information can be may be collected through the use of survey research: attitudes, beliefs, behavior, and attributes. Since I am interested in these types of information, the survey approach was appropriate. Correlational research also has a number of desirable qualities. For example, Deshpandé (1982) points out the ease with which a researcher can reach a geographically widespread population at a relatively low cost. Campbell (1955) suggests that the survey approach makes it easier to collect data from selected respondents that are familiar with, or experts in, the phenomenon under study.

The survey approach used here employs a self-report questionnaire that was administered to an online research panel comprised of key informants. The questionnaire is comprised of measures that attempt to capture the constructs of interest (please see section 4.3 for a detailed discussion).

4.2.4. Key Informants

Since innovation activities within a firm can be managed and undertaken through multiple people and approaches (Cooper 2001), accurately defining the key respondent was important. For the purposes of this study, the key respondents are broadly described as those individuals within a firm that are directly involved in decision-making behavior related to innovation activities. Since, these individuals can be from various departments and could potentially hold multiple differing titles, it can be difficult to narrow the key respondents by job title and functional department. Therefore I adopt a more holistic approach.

For the purposes of this dissertation, I include all the following job titles to describe the key respondent - *chief innovation officer, director of product management, new product manager/leader, new projects manager/leader, innovation manager/leader, innovation team manager/leader, product development manager/leader, senior product manager, director/manager of research and development.* However, this approach raised issues with my decision to employ a research panel. The main issue was the cost associated with defining a target demographic with an extremely low rate of incidence in the general population.

As a result, I had to adopt a more lax description of the key respondent and settled on product managers. However, since not all product managers may be involved in innovation related decision-making, I implemented measures to qualify potential key respondents for the study. Based on the recommendations of Kumar, Stern, and Anderson (1993), I employ key informant qualification questions within the questionnaire that are intended to assess the product managers level of involvement in innovation related decision making. These screening questions are discussed in detail in Chapter V.

4.2.5. Response Rate and Non-Response Bias

The use of a research panel, often times results in extremely high response rates. This is an inherent quality of using such panels. However, a discussion of response rates is essential to any research that employs a survey approach.

Non-response bias is an important phenomenon that needs to be examined in the context of survey research. Non-response bias refers to the systematic difference between the respondents and those that do not respond to the study (Parsuraman 1991). Unless it is examined, the results could be tainted, and therefore limits the inferences that can be made based on the data.

There are multiple approaches to test for non-response bias. This dissertation will employ one in particular that has been widely adopted in other research. Based on the recommendations of Armstrong and Overton (1977), the primary test for potential non-response bias will look for systemic differences between early and late respondents. A chi-square difference test can be employed to check for this when responses are split into

groups based on early and late completions. If the chi-square difference test is non-significant, we can safely assume that there is no non-response bias in the data. However, one should keep in mind that when using an online research panel, such differences are likely to be non-significant anyway.

4.3. Measurement

The following sub-sections review all the variables included in this study. Based on an extensive review of the literature, the measures were either adopted as is, adapted, or newly developed. I assess each measurement variable in terms of their psychometric qualities. As mentioned previously, in some instances this dissertation has developed and adopted completely new measures. The necessary justifications for doing so are discussed where necessary. Both independent and dependent measures are operationalized using multi-item measures based on the recommendations of Bagozzi et al. (1991) and Churchill (1979).

4.3.1. Dependent Variable

Front-end of innovation performance is the dependent variable in this dissertation. It is defined as the overall evaluation of the quality of the product concepts produced by the front-end of innovation process. This represents the firm's overall performance in its front-end activities. However, extant research has not adequately attempted to develop a multi-item measure for this variable. In fact, the norm in innovation research has been to adopt objective measures of innovation performance (e.g. Hurley and Hult 1998). While this is effortlessly implemented in research studying innovation as a whole, or in research looking at latter end stages, it is not very effective in front-end innovation research. The

only related subjective measures that have seen widespread acceptance are those that seek to ascertain new-product advantage (Slotegraaf and Atuahene-Gima 2011).

Based on the lack of well-developed multi-item measure for front-end innovation performance, this dissertation attempts to test and validate a completely new measure. However, since developing a completely new measure for the dependent variable in this dissertation could prove risky, a multiple scale approach was used. Published research has sometimes used subjective scales in addition to attribute and quantitative scales when looking at key variables that could all at once be measured based on a subjective, attribute, or quantitative approach (Verhorn, Herstatt and Naghira 2008).

Therefore, I develop three new measures for front-end of innovation performance. As shown in Tables 4-1, 4-2, and 4-3, there is a subjective scale, an attribute based scale, and a quantitatively oriented scale respectively. All scales employ seven-point likert type items. The items were chosen based on the scale development techniques suggested by Churchill (1979) and Gerbing and Anderson (1988). All scales will be subject to standard psychometric analysis in order to determine the scales properties.

Table 4-1

FRONT-END OF INNOVATION SCALE (SUBJECTIVE VERSION)

Item	Statement
Please select the appropriate response in the context of your innovation activities especially its early stages (also referred to as the front-end of innovation).	
1	The front-end results of new product projects I've led have been really good.
2	Front-end idea screening is considered a strength here.
3	Front-end concept development processes are considered a strength here.
4	When I think about our NPD processes, the front-end activities are excellent.
5	In our front-end process, we excel at producing solid product concepts for future development.

Original Scale

Table 4-2

FRONT-END OF INNOVATION SCALE (ATTRIBUTE VERSION)

Item	Statement
Please select the appropriate response in the context of your innovation activities especially its early stages (also referred to as the front-end of innovation).	
1	Product strategies that result from our front-end process are clear.
2	Our front-end idea screening produces sharp product definitions.
3	Product concepts that we recommend for further development are financially feasible.
4	A high percentage of our recommended concepts get funded for product development.
5	In our front-end process, we excel at producing clear product definitions.

Original Scale

Table 4-3

FRONT-END OF INNOVATION SCALE (QUANTITATIVE VERSION)

Item	Statement
1	How many new ideas were generated in your front-end process during the last 3/6/12/18 months?
2	How many ideas emerged from your front-end processes ready for development in the last 3/6/12/18 months?
3	What percentage of product concepts produced by your front-end process actually received funding during the last 3/6/12/18 months?
4	What percentage of product concepts produced by your front-end process during the last 3/6/12/18 months?
5	What percentage of your product concepts were abandoned or discarded during the past 3/6/12/18 months?

Original Scale

4.3.2. Predictor Variables

Fear of negative evaluation was measured using a four item multi-item measure (see Table 4-4). The scale was originally developed by Rodebaugh et al. (2004) and is called the brief fear of negative evaluation scale.

The brief fear of negative evaluation scale has been widely adopted in a variety of psychological studies and its psychometric properties have been largely confirmed as adequate to good (Orsillo 2001). For the purposes of the current study, the original scale has been modified slightly to better fit the context of innovation. In addition, the scale has been shortened to keep the overall survey instrument short in length. The eight items that were dropped from the original scale were screened out once it was determined that they either shared considerable similarities with other items, or had little relevance in the current context.

Table 4-4

FEAR OF NEGATIVE EVALUATION SCALE

Item	Statement
When I make decisions on new product ideas:	
1	I am afraid that others will criticize decisions I have made
2	I worry a lot about what my supervisors would think of my decision.
3	I worry a lot about what my co-workers would think of my decision.
4	These decisions are open to criticism by others.

Rodebaugh et al. (2004) (adapted)

Though an extant scale has been adopted to measure FNE, this dissertation once again attempts to develop a new scale in keeping with the definition of FNE used herein; the "apprehension and distress arising from concerns about being judged disparagingly or hostilely by others" (Carleton et al. 2006), and the context of the current study (see Table 4-5).

The same procedures, as mentioned earlier, for the development of the new front-end of performance scale were used here again. Upon data collection, the new scale will be assessed via exploratory and confirmatory analysis to ascertain its psychometric properties.

Table 4-5

ALTERNATIVE FEAR OF NEGATIVE EVALUATION SCALE

Item	Statement
When I make decisions on new product ideas:	
1	I worry that the innovation related decisions I make might lead to ridicule within the company.
2	In our innovation process, out-of-the-box decisions may be negatively received
3	To gain positive feedback, innovation decisions must be based on accepted criteria.
4	To avoid negative feedback by others in the firm, I usually approve the most defensible innovation ideas.

Original Scale

This dissertation defines perceived competence as an "individual's sense of skill, knowledge and understanding over a given decision context" (*adapted from* Heath and Tversky 1991). This dissertation develops a new five-item scale to measure a decision-makers sense of competence (see Table 4-6). There exist other scales in the literature, most notably the perceived competence scale (PCS) used in research employing self-determination theory (e.g. Williams and Deci (1996). However its psychometric properties are poor and unreliable, and the scale items themselves poorly fit the current study.

Therefore, a new scale to measure perceived competence of the decision-maker was developed. All items were generated using the same scale development procedures mentioned previously. The new scale will have to be subject to through psychometric testing upon data collection. However, it should be noted that the new scale employs items that fit better with the overall theme of the current study.

Table 4-6

PERCEIVED COMPETENCE SCALE

Item	Statement
On the following questions please select your level of expertise, knowledge, or experience.	
1	I have many years of experience in innovation.
2	I am very knowledgeable about new product development.
3	I consider innovation an area in which I know what I am doing.
4	I have developed expertise in managing innovation.
5	I have developed expertise in managing product development.

Original Scale

For the ambiguity aversion construct, this dissertation adopts a completely new measure. It is comprised of five seven-point likert type items. There exists a well known tolerance of ambiguity scale developed by Budner (1962). This scale was refined most recently by McLain (2009). However the tolerance for ambiguity scale is a poor fit for this dissertation in a number of important areas. First, it is developed on a psychological conceptualization of ambiguity which is different from the conceptualization adopted in this dissertation. This dissertation draws its conceptualization of ambiguity based on the works of Knight (1921) and Ellsberg (1961), where the theoretical underpinnings are based on utility theory and decision theory.

Second, aversion and tolerance to ambiguity are actually two different concepts altogether. This dissertation defines ambiguity aversion as the "preference for options involving clear probabilities to options involving vague probabilities" (Trautmann et al.

2008). Tolerance for ambiguity is best defined as "an orientation, ranging from aversion to attraction, toward stimuli that are complex, unfamiliar, and insoluble" (McLain 2009).

Based on this reasoning, I decided that a new measure had to be developed. In selecting a pool of items to develop the new measure, extreme care was given to ensure that the measures matched up well with conceptualization of ambiguity aversion adopted in this dissertation. As a result a number of items from McLain's (2009) tolerance for ambiguity scale that related with our conceptualization were adopted and slightly modified for better contextual fit. Table 4-7 provides a concise overview of the newly developed multi-item scale. Being a newly developed measure, its psychometric properties are yet to be examined via exploratory and confirmatory factor analysis.

Table 4-7

AMBIGUITY AVERSION SCALE

Item	Statement
In relation to innovation activities:	
1	When it comes to uncertain outcomes, I need to know the odds for and against.
2	Problems that must be considered from multiple viewpoints are a little threatening.
3	I enjoy tackling problems that are ambiguous. (R)
4	Before I can make a decision, understanding the probable outcomes must come first.
5	I would rather avoid solving a problem that must be viewed from several different perspectives.

Adapted Scale

The final predictor variable is decision-making comprehensiveness. It is defined as the "degree to which the team is exhaustive as it considers multiple approaches, courses of action, and decision criteria in its strategic decision making" (Slotegraaf and

Atuahene-Gima 2011, p. 97). I adopt an existing measure of decision-making comprehensiveness. The scale comprises of four 7-point likert style items. Published research shows the scale to have high composite reliability and other admirable psychometric properties (Slotegraaf and Atuahene-Gima 2011). Table 4-8 provides an over view of the decision-making comprehensiveness scale.

Table 4-8

DECISION-MAKING COMPREHENSIVENESS SCALE

Item	Statement
When I've been the decision maker of a new-product development team, we:	
1	Develop many alternative courses of action.
2	Use multiple criteria for eliminating possible courses of action.
3	Engage in extensive and in-depth analysis of all available strategic options
4	Thoroughly examine multiple explanations for problems and opportunities.

Slotegraaf and Atuahene-Gima (2011)

4.3.3. Moderator Variables

The main moderating variable in the conceptual model is innovation culture. This dissertation defines innovation culture as the "openness to new ideas as an aspect of firms' organizational culture" (Hurley and Hult 1998, p. 44).

In operationalizing innovation culture, Hurley and Hult (1998) use a measure developed by Burke (1969) that attempts to measure an individual's perception of group culture. However, I do not use Burke's (1969) scale. While Burke's (1969) scale has items intended to assess innovativeness, it also comprises four other dimensions of

culture (such as power sharing) that are irrelevant to the current study. Therefore it was decided to search for other measures that are a better fit to the conceptualization of innovation culture adopted in this dissertation.

Multiple scholars have attempted to develop multi-item measures for innovation culture (Dobni 2008; Ahmed and Wang 2004). I adopt a four-item measure of innovation culture from Dobni (2008). The scale uses likert type items. This measure was adopted based on the good psychometric properties exhibited by the scale ($\alpha > .70$); all factor loadings greater than .70) in addition to its good fit with my conceptualization of the innovation culture construct.

Table 4-9

INNOVATION CULTURE SCALE

Item	Statement
In my company:	
1	Innovation is an underlying culture and not just a word.
2	Our senior managers are able to effectively cascade the innovation message throughout the organization.
3	Innovation is a core value.
4	We have an innovation vision that is aligned with projects, platforms, or initiatives.

Dobni (2008)

Capacity to innovate is defined as the "ability of the organization to adopt or implement new ideas, processes, or products successfully" (Hurley and Hult 1998, p. 44). In their work, Hurley and Hult (1998) adopt an objective measure of capacity to innovate. They operationalize the construct in terms of "the number of new ideas that had been

adopted by the organization and recognized by a formal suggestion award program" (Hurley and Hult 1998, p. 48). This approach is not as feasible for the purposes of this dissertation.

In order to measure capacity to innovate, a completely new scale was developed. It consists of four likert type items. The items were chosen and refined based on the same recommendations used for other new scales in this dissertation. Table 4-10 provides a summary of the items. As with other new scales, thorough exploratory and confirmatory factor analyses need to be performed in order to assess its psychometric properties.

Table 4-10

CAPACITY TO INNOVATE SCALE

Item	Statement
In my company:	
1	We find it easy to adopt new processes.
2	We definitely work at creating new ways to work.
3	Our skills translate into new innovations that benefit customers.
4	Innovation requires dynamic capabilities that we possess.

Original Scale

4.3.4. Control Variables

A number of key control variables are incorporated in the instrument. This was done in order to control for extraneous effects that might have an undue influence on the data and the conceptual model. The variables that are controlled in this study include,

firm size, managerial traits (like experience and education), and environmental factors (including market turbulence and technological turbulence). Each of these are discussed in succession.

It is possible when using online research panels to end up with data from a wide variety of firms in terms of size. Innovation could possibly have different roles in different sized firms. Therefore, I decided to control for firm size. Firm size was measured using the number of employees and annual sales as indicators (see Table 4-11). This is common practice in the marketing literature (Gammoh et al. 2006).

Individual manager traits are also controlled in the current study for multiple reasons. First, such measures serve to screen individuals who are not key decision-makers in the innovation context. This is important since the current study uses an online research panel to collect data. Second, there is likely to be differences in terms of managerial tenure and competency in terms of how individual managers deal with ambiguity. While this is not the primary research agenda in this study, it was nevertheless important to gain insights into such areas.

Table 4-11

FIRM-LEVEL CHARACTERISTICS MEASURES

Item	Statement
1.	What are the approximate annual sales of your firm? ❍ Less than $500,000 ❍ Between $500,000 and $999,999 ❍ Between 1 million and 10 million US Dollars ❍ Between 10 million and 50 million US Dollars ❍ Between 50 million and 100 million US Dollars ❍ Between 100 million and 500 million US Dollars ❍ Between 500 million and 1 billion US Dollars ❍ Between 1 billion and 10 billion US Dollars ❍ Between 10 billion and 50 billion US Dollars ❍ Over 50 billion US Dollars
2.	What is the approximate number of employees in your firm? ❍ Less than 25 employees ❍ Between 25 and 100 employees ❍ Between 101 and 200 employees ❍ Between 201 and 500 employees ❍ Between 501 and 800 employees ❍ Between 801 and 1000 employees ❍ Between 1001 and 5000 employees ❍ Over 5000 employees
3	How long has your firm been in business? _____ years
4	How long has your firm operated in this industry? _____ years

Table 4-12

INDIVIDUAL MANAGER TRAIT MEASURES

Item	Statement
1	How long have you been employed in this industry? _____ years _____ months
2	How long have you been employed with your current firm? _____ years _____ months
3	How long have you been involved in innovation activities in your career? _____ years _____ months
4	How long have you been involved in innovation activities with your firm? _____ years _____ months
5	How many new-product projects have you been involved in during you career?
6	How many new-product projects have you been involved in during you time with your current firm?

Measures of individual managerial traits and competency were adopted from Kumar, Stern and Anderson (1993). All items were slightly modified to fit the innovation context. The individual manager competency scale uses nine 7-point likert type items. Table 4-12 and 4-13 provides an over view of both the trait and competency measures respectively.

Table 4-13

INDIVIDUAL MANAGER COMPETENCY SCALE

Item	Statement
I have adequate knowledge to assess this firm's:	
1	Experience with respect to managing innovation activities
2	Skills with respect to managing innovation activities
3	Capabilities with respect to managing innovation activities
4	Motivations with respect to managing innovation activities
5	Motivations with respect to profit goals for one or more products
6	Motivations with respect to reacting to the competition
7	Goals with respect to the future direction for product innovation activities
8	Motivations with respect to cost control goals for product innovation activities
9	Products' quality

Original Scale

The final set of control variables adopted in this study pertains to environmental factors. Four variables were considered including market turbulence, technological turbulence, and environmental uncertainty. These measures were included in keeping with common practices adopted in the innovation literature (Slotegraaf and Atuahene-Gima 2011). All measures were adopted from well-tested scales used in the published literature. Market turbulence and technological turbulence were adopted from Jaworski

and Kohli (1993). Environmental uncertainty was operationalized using four 7-point likert type items adapted from previous research (Atuahene-Gima and Murray 2004; Jaworski and Kohli 1993). All scales employ 7-point likert type items (see Table 4-14).

Table 4-14

ENVIRONMENTAL FACTORS SCALE

Item	Statement
	MARKET TURBULENCE
1	In our kind of business, customers' product preference change quite a bit over time
2	Our customers tend to look for new products all the time
3	We are witnessing demand for our products and services from customers who never bought them before
4	New customers tend to have product-related needs that are different from those of our existing customers
5	We cater to many of the same customers that we used to in the past (R)
	TECHNOLOGICAL TURBULENCE
1	The technology in our industry is changing rapidly
2	Technological changes provide big opportunities in our industry
3	A large number of new product ideas have been made possible through technological breakthroughs in our industry
4	Technological developments in our industry are rather minor (R)
	ENVIRONMENTAL UNCERTAINTY
1	Changes in the marketing practices of our competitors is easy to predict (R)
2	The actions of our competitors are easy to predict (R)
3	Demand and consumer preferences are easy to predict (R)
4	Changes in product technology within this industry are easy to predict (R)

4.3.5. Survey Development

As mentioned earlier, my data collection plan for this dissertation was to use an online research panel. This implies that the survey will be administered electronically. Even though this method does not rely on traditional paper and pencil surveys, there are certain recommendation applied to paper and pencil surveys that should be employed in designing the instrument.

Based on the recommendations of Dillman (1978), and to improve response rates, several procedures were adopted in the development of the instrument. For example, particular attention was given to ensure that questions did not appear vague or incomprehensible. This was a particular issue in that multiple questions employ the word 'ambiguity' which could potentially be interpreted in a number of ways.

Another concern was overall questionnaire length. This issue was largely subdued through the use of shorter scales where possible. However, since the administration of the instrument is largely outside my control (due to the use of an online research panel, Dillman's (1978) recommendations on maintaining a professional appearance could not be followed.

The final instrument was pre-tested using a three-stage process. First, a group of marketing scholars assessed the instrument to check for face validity, overall structure and content. Their feedback was used to make changes to the instrument. The second stage involved pre-testing the instrument with a convenience sample of MBA students at a large mid-western university. This was done to ensure overall clarity of the questions and overall structure of the survey. Following the pre-test, the respondents were asked to

rate the survey on 1)the extent to which the survey was well organized and easy to read, 2) the length of the questionnaire and 3) the clarity of the instructions provided. Following this, the instrument was finally presented with a small group of industry professionals. Dillman's (1978) recommendations on professional questionnaire appearance were also assessed during this stage, although as mentioned earlier, this did not factor in the online version of the instrument. Once again, the procedures were the same as those employed with the MBA students. A copy of the instrument is attached in Appendix A.

4.4. Data Analysis Plan

The data analysis plan in this dissertation follows a number of important steps and procedures. First analytical datasets were created from the raw data so as not to corrupt the raw data file. The first step was to assess the descriptive statistics of the data followed by a test for non-response bias. All scales were then examined to assess their psychometric properties. This included exploratory and confirmatory factor analysis in order to assess inter-item correlations, coefficient alpha and discriminant validity. Verifying unidimensionality, based on the measurement model developed for the confirmatory factor analysis, assessed convergent validity.

Finally all proposed hypotheses and relationships were examined using hierarchical regression using three stage least squares. Using this approach has a number of advantages over the use of structural models. Primarily, the three stage least squares approach in SAS affords the analyst flexibility when analyzing moderation through the use cross-product terms. This can be accomplished while still maintaining simultaneous

estimation of the hierarchical regression parameters. However, this method does not allow the integration of the measurement model into an overall structural model.

4.5. Summary

This chapter has provided a detailed overview of the research design and methodology employed in this dissertation. This included discussions on the key respondents, measures, and proposed data analysis techniques. The next chapter will provide a detailed account of the results of the data collection and how it relates to the conceptual model outlined in this dissertation.

CHAPTER V

DATA ANALYSIS AND RESEARCH FINDINGS

5.1. Introduction

This chapter is organized into three major sections. The first of these sections provides a detailed description of the sample. This includes a discussion of key sample characteristics like type of firms sampled, level of managerial experience in relation to innovation activities, and other key demographics.

The second section describes those aspects related to the measurement model. For instance, psychometric properties and other key indicators of the overall quality of the measurement model are discussed. This is in addition to pointing out the results of all exploratory factor analyses (EFAs) and confirmatory factor analyses (CFAs).

The final section is concerned with testing the hypotheses outlined in the previous chapter. This includes (1) analyzing the relationship between ambiguity aversion and its proposed antecedents, (2) assessing the moderating role of innovation culture on the

relationship between ambiguity aversion and its antecedents, (3) determining the effect of ambiguity aversion on decision making comprehensiveness, and finally (4) examining the role of the aforementioned constructs on front-end of innovation performance as outlined in the conceptual model discussed previously. As pointed out in Chapter IV, all hypothesis testing was performed via simultaneously estimated regression equations using 3SLS estimation technique.

5.2. Sample Characteristics

As mentioned previously, the data for the current study was collected via a panel provider by administering an online survey. In addition to answering items related to the constructs of interest, respondents were also required to provide information about themselves. In the following sections, I describe in detail the various sample characteristics of importance such as the makeup of firms where the respondents worked, their overall level of managerial competence, their experience with regards to innovation etc.

5.2.1. Respondent Screening

In order to ensure that survey respondents had adequate experience in regards to innovation, a screening question was employed. This is important as it ensures the integrity and credibility of the data collected and aids in external validity (specifically population validity). The screening question was presented to respondents immediately following the participant information sheet that described the study (a requirement as per IRB). Table 5-1 shows the items included in the screening question. The first three

options qualified participants to take the survey, while the last two options concluded the survey for those respondents that chose it.

This approach was adopted instead of qualifying respondents based on their job title. The justification for this decision is based upon the fact that there are numerous titles that individual mangers related to innovation might hold. From firm-to-firm these may vary dramatically. For example, in some firms a brand manager might be in charge of innovation related activities, while in another firms it might be the R&D manager. Due to these idiosyncrasies, I decided that the best way to ensure that we tap into the correct sample frame would be to employ a screening question that qualified participants based on their active role in innovation. This approach also aided in screening out participants who have a limited role in innovation decision-making who might have otherwise qualified if they had a misleading job title.

Table 5-1

BREAKDOWN BY SCREENING QUESTION

Question	Frequency	Percentage
I am the sole decision maker regarding innovation/ new product ideas **[QUALIFY]**	48	12.9
I make the final decision regarding innovation/ new product ideas with input from staff/management **[QUALIFY]**	46	12.3
I help reach the final decision regarding innovation/ new product ideas as part of a group/committee **[QUALIFY]**	84	22.5
I provide input toward decisions regarding innovation/ new product ideas **[TERMINATE]**	124	33.2
I have no input into decisions regarding innovation/ new product ideas **[TERMINATE]**	70	18.8

A total of 373 participants were invited by Research Now® (the panel provider) to take the online survey which was administered on Qualtrics®. Of these, 178 respondents qualified based on the screening criteria and were presented with the questionnaire. This resulted in a total qualifying rate of 47.7%. Those that did not qualify were thanked for their participation and were not shown the survey instrument.

5.2.2. Firm Characteristics

The respondents in the current study come from a wide representation of firms based in the United States. Questions meant to assess the characteristics of the firms included items related to firm size as measured by number of employees, annual sales generated, number of years the firm has been active etc. The questions related to number of employees and annual sizes were adopted from the U.S. Economic Census. This allows us to compare our sample with that of the wider population in terms of the makeup of firms represented in the study.

From the total 178 responses received, 175 respondents provided information regarding their firm's annual sales. Approximately 60% reported annual sales of less than 10 million U.S. Dollars, with the largest category of firms reporting annual sales less the 500,000 U.S. Dollars (29.7% of the total sample). This is represented in Table 5-2 which shows a frequency distribution of firms in the sample broken down by annual sales per year. When compared to the total population of U.S. companies (by comparing the sample to Economic Census data) it becomes clear that our sample contains firms that have higher annual sales. In other words, the current sample is characterized by a larger

proportion of firms ($\chi^2 = 42.58(1)$, $p = .000$, see Table 5-3) with higher annual sales when comparing the distribution to Economic Census data.

Table 5-2

FIRM CHARACTERISTICS

BREAKDOWN BY APPROXIMATE ANNUAL SALES

Breakdown	Frequency	Percentage
Less than $500,000	52	29.7
Between $500,000 and $999,999	15	8.6
Between 1 million and 10 million US Dollars	33	18.9
Between 10 million and 50 million US Dollars	24	13.7
Between 50 million and 100 million US Dollars	7	4
Between 100 million and 500 million US Dollars	21	12
Between 500 million and 1 billion US Dollars	4	2.3
Between 1 billion and 10 billion US Dollars	8	4.6
Between 10 billion and 50 billion US Dollars	9	5.1
Over 50 billion US Dollars	2	1.1

Table 5-3

FIRM CHARACTERISTICS

ANNUAL SALES ANALYSIS

Breakdown	Less than $500,000 p.a.	Less the $10,000,000 p.a.
Overall population of U.S. firms*	3,699,401 (61.15%)	5,852,200 (96.73%)
Firms represented in the sample	52 (29.71%)	44 (57.14%)

*Source: 2007 Economic Census - U.S. Census Bureau

I also analyzed firm size based on the data collected (N=177). Size was measured by way of the number of employees that a firm had on payroll. As can be seen from Table 5-4 below, the current sample has a spread of firms ranging from small to large size. According to the frequency distribution, firms with less than 25 employees represented the largest category in the sample with 43.5% of the total firms falling within this group. Nevertheless, the sample also included firms of both medium and large sizes.

Table 5-4

FIRM CHARACTERISTICS

BREAKDOWN BY NUMBER OF EMPLOYEES

Breakdown	Frequency	Percentage
Less than 25 employees	77	43.5
Between 25 and 100 employees	30	16.9
Between 101 and 200 employees	10	5.6
Between 201 and 500 employees	16	9
Between 501 and 800 employees	6	3.4
Between 801 and 1000 employees	8	4.5
Between 1001 and 5000 employees	14	7.9
Over 5000 employees	16	9

It is important to point out that the current sample differs from the population of all firms in terms of size. While 99.7% of all U.S. companies report less than 500 employees (2007 U.S. Economic Census), only 75.14% of the firms included in this study have less than 500 employees. In other words, there is a bigger proportion of large firms (χ^2 = 20731.26(1), p = .000, see Table 5-5) that have been included in the current study.

Table 5-5

FIRM CHARACTERISTICS

NUMBER OF EMPLOYEES ANALYSIS

Breakdown	Less than 500 employees	500 employees or greater
Overall population of U.S. firms*	6,031,344 (99.69%)	18,311 (0.31%)
Firms represented in the sample	133 (75.14%)	44 (24.86%)

*Source: 2007 Economic Census - U.S. Census Bureau

Ultimately, the discrepancies in terms of firm characteristics when comparing the current sample to census data can be explained based on the selection and screening criteria employed for determining the sample of managers. It is likely that the narrowly defined criteria for selecting and qualifying managers may have eliminated a large proportion of the smaller firms. Nevertheless, the data shows acceptable overall standards in terms of firm characteristics to proceed with further analysis.

5.2.3. Respondent Characteristics

Within the survey instrument, multiple questions were incorporated to assess respondent characteristics. These included items related to work experience, managerial competence, experience with regards to innovation, tenure at firm, etc. In addition to the screening question that was employed, these items play a pivotal role in determining the quality of the sample with respect to the current study. Especially of interest here is obtaining the correct key informants to participate in the study; since ensuring that study participants are indeed managers with a key role in innovation decision-making is crucial.

Table 5-6 provides an analysis of the nine 7-point likert type items that assess managerial competence with respect to innovation activities. These included items such as having adequate knowledge of the firm's experience with innovation activities, knowledge with regards to the firm's capabilities in regards to innovation, and having adequate knowledge with respect to competitive reactions etc. The reported results are definitely positive. An overwhelming majority of participants reported extensive experience in the innovation domain. For example, over 65% of all participants chose either *agree (6)* or *strongly agree (7)* on every single item. A very small proportion of respondents chose below *neutral (4)* on each of these items.

Another way to assess the data is to analyze the reported means of each item. Once again looking at Table 5-6, the mean for each item is 5.78 or greater (t-tests for mean greater than 4 was performed with results reported in Table 5-6). This suggests that on average our sample had a high level of overall competence or adequate knowledge when it comes to their firm's innovation activities and overall objectives and goals. One explanation for the overall high quality of the sample in regards to managerial competence is the use of the screening question. It is likely that it helped to eliminate those potential respondents that might have been ancillary to overall decision-making related to innovation activities, and only qualifying managers with in depth experience and knowledge of their firms innovation activities.

TABLE 5-6

MANAGERS REPORTED COMPETENCE LEVELS

Statement	Mean	Response Frequency (Percentage) Strongly Disagree 1	2	3	4	5	6	Strongly Agree 7
I have adequate knowledge to assess this firm's:								
Experience with respect to managing innovation activities.	5.88*	4 (2.3)	1 (0.6)	2 (1.1)	19 (10.8)	28 (15.9)	47 (26.7)	75 (42.6)
Skills with respect to managing innovation activities.	5.85*	3 (1.7)	2 (1.1)	0 (0.0)	17 (9.7)	35 (19.9)	53 (30.1)	66 (37.5)
Capabilities with respect to managing innovation activities.	5.87*	2 (1.1)	1 (0.6)	1 (0.6)	15 (8.5)	37 (21.0)	59 (33.5)	61 (34.7)
Motivations with respect to managing innovation activities.	5.97*	2 (1.1)	0 (0.0)	1 (0.6)	18 (10.2)	34 (19.3)	44 (25.0)	77 (43.8)
Motivations with respect to profit goals for one or more products.	5.98*	2 (1.1)	1 (0.6)	1 (0.6)	19 (10.8)	28 (15.9)	45 (25.6)	80 (45.5)
Motivations with respect to reacting to the competition.	5.86*	4 (2.3)	0 (0.0)	3 (1.7)	16 (9.1)	28 (15.9)	61 (34.7)	64 (36.4)
Goals with respect to the future direction for product innovation activities.	5.91*	3 (1.7)	0 (0.0)	4 (2.3)	10 (5.7)	32 (18.2)	63 (35.8)	64 (36.4)
Motivations with respect to cost control goals for product innovation activities.	5.78*	4 (2.3)	0 (0.0)	4 (2.3)	17 (9.7)	36 (20.5)	52 (29.5)	63 (35.8)
Products' quality.	6.05*	2 (1.1)	0 (0.0)	2 (1.1)	16 (9.0)	26 (14.6)	47 (26.4)	83 (47.2)

* A one sample t-test of $\mu>4$ was significant at $p < .001$(one-tailed)

Apart from the questions related to overall competence, respondents were also asked how long they have been involved in innovation related activities. Respondent's years of experience ranged from less than one year up to 50 years of experience in innovation. Taken together, participants in the study reported a total of 2,435 years of experience in innovation related activities. This averaged out to approximately 14 years of experience per respondent.

The questionnaire also asked participants to report how many new-product projects they had participated in during their career. The data shows that 98% of all respondents had experience in new-product projects ranging from a minimum of 1 to a maximum of 1200. The average number of new-product projects that participants had been involved in was 53.46 projects. Based on the preceding analysis, it is clear that the sample has adequate experience and knowledge with regards to innovation activities.

5.3. Data Cleaning and Univariate Analysis

The following section discusses the procedures employed to clean the data set. This included missing value analysis and univariate analysis to determine outliers and assess the normality of data.

5.3.1. Missing Value Analysis

While a total of 178 responses were collected, due to incomplete responses, 2 cases were dropped from further analysis. The dropped cases (reference # 43 and 80) had greater than 15% of their total values missing within them. This left a total of 176 usable cases for further analysis.

There were a further 4 cases with missing values (reference # 8, 67, 104, and 123). These cases had between 2.4% and 7.1% of their total values missing. Since this was a rather small amount and restricted to secondary variables of interest, the decision was employed to impute the missing values via mean substitution.

5.3.2. Outlier Analysis

An outlier is an observation that is significantly different from the other observations in the data set. This is usually apparent as an 'extreme' case on one or more of the measured variables. Outlier analysis was performed by analyzing box and whisker plots. At a later stage I briefly examined scatter plots of studentized residuals for each variable using a +/- 3 standard deviation cut off point to further look for outliers.

The outlier analysis revealed a number of cases that warranted further attention. Specifically, 4 cases (reference # 27, 63, 125, and 177) exhibited extreme values that would have proven detrimental during further stages of analysis like hypothesis testing. Therefore the decision was made to drop these cases entirely from further analysis. Ultimately, this left N=172 cases in the analytical data set.

5.3.3. Other Univariate Tests and Testing Basic Assumptions

The next step involved a thorough examination of univariate statistics for each variable of interest. Measures of central tendency for each item, including histograms were examined. I also examined frequency distributions for each item. This was an elementary step undertaken to ensure that all statistics were at acceptable level and to

ensure that there weren't any basic underlying anomalies in the data set. It was also at this stage that all items that need to be reversed were managed.

The measures of central tendency (mean, median, and mode) exhibited nothing out of the ordinary. Histograms for each item were used to determine the distribution of the data. The results were again as expected. Skewness and kurtosis for each item's distribution was also examined and once again were within reasonable expectations for the data.

5.4. Psychometric Properties and Measurement Quality Assessment

Of key importance to any study based on the survey method and statistical inference is the psychometric assessment of each construct. This includes an in depth analysis of the measurement model. The following sections discuss in detail these aspects with individual attention provided to each variable of interest. For each variable, I detail the various issues related to construct validation and reliability, dimension reduction via exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). Issues related to convergent validity and discriminant validity are also discussed.

As pointed out in the previous chapter, the variables of interest are fear of negative evaluation, perceived competence, ambiguity aversion, decision-making comprehensiveness, innovation culture, capacity to innovate, and front-end of innovation performance. Each measure is reflective and was measured using multiple 7-point likert type items.

5.4.1. EFA and Reliability Analysis

All variables were subject to an EFA. Unless otherwise specified, all EFAs were run using principal component analysis method with no rotation in SPSS 21. Upon performing the EFA, I examined the principal components to examine each item's factor loading. A minimum factor loading of 0.5 was deemed acceptable at this early stage of measurement building The Eigen value greater than 1 cut-off was employed to determine the number of principal components extracted and the total variance explained by the principal component was assessed. Performing the EFA helps to evaluate construct validity for each variable of interest.

Additionally, I also examined Cronbach's (coefficient) alpha (α) and item-to-total correlation to determine reliability (also known as internal consistency reliability). Based on Voss, Stem and Fotopolous (2000) scales were considered reliable based on the observed level of alpha given the distribution of the responses, the length of the scale, and response patterns in the data. In order to establish reliability, scholars will often look for at least a 0.70 coefficient alpha in order to deem a scale reliable. This is as per the recommendations of Nunnally (1978). Below I present EFA results and reliabilities for each of the variables included in the conceptual model.

Perceived Competence (PCOMP). Upon conducting an EFA for this construct, one principal component was extracted with an Eigen value of 4.21 that explained 84.22% of the total variance. All 5 items loaded onto the principal component at above 0.9 (see Table 5-7). Internal consistency reliability was also determined to be excellent based on the high coefficient alpha and item-to-total correlations.

Table 5-7

EXPLORATORY FACTOR ANALYSIS AND RELIABILITY ANALYSIS

PERCEIVED COMPETENCE

Scale Items		Factor Loadings	Item-Total Correlation
Manager's Perceived Competence			
PCOMP1		0.914	0.863
PCOMP2		0.945	0.911
PCOMP3		0.908	0.854
PCOMP4		0.916	0.867
PCOMP5		0.906	0.853
Eigen Value	4.21		
Variance Explained	84.22%		
Cronbach's Alpha	0.953		

Fear of Negative Evaluation (FNE). As can be seen in Table 5-8, the EFA performed on the items for fear of negative evaluation extracted one principal component with an Eigen value of 3.24. This principal component explained 81.18% of the total variance. FNE1,2, and 3 had factor loadings above 0.91 while FNE4 loaded at 0.839. This scale also exhibited high reliability based on the reported coefficient alpha and item-to-total correlations.

A secondary scale was proposed in the previous chapter to measure fear of negative evaluation. However, this secondary scale did not exhibit acceptable psychometric properties based on the EFA and reliability analysis. For instance, coefficient alpha was considerable lower (0.68) for the alternative scale compared to the primary scale discussed here and shown in Table 5-8 below. Additionally, the factor loadings were low and the total variance explained by the extracted factor was only 52%.

As a result of these findings, this alternative scale was dropped from further analysis and only the primary scale was used to represent the fear of negative evaluation construct.

Table 5-8

EXPLORATORY FACTOR ANALYSIS AND RELIABILITY ANALYSIS

FEAR OF NEGATIVE EVALUATION

Scale Items		Factor Loadings	Item-Total Correlation
Fear of Negative Evaluation			
FNE1		0.911	0.837
FNE2		0.925	0.856
FNE3		0.926	0.860
FNE4		0.839	0.731
Eigen Value	3.24		
Variance Explained	81.18%		
Cronbach's Alpha	0.922		

Innovation Culture (ICL). As mentioned in the previous chapter, innovation culture was measured using 4 items adopted from Dobni (2008). These items when subject to an EFA resulted in a one principal component solution with an Eigen value of 3.01 that explained 75.46% of the variance. All factor loadings were above 0.91 except for ICL4 which loaded at 0.839. Cronbach's alpha was 0.92 while item-to-total correlations were all above 0.73. This suggest good internal consistency reliability. Table 5-9 provides a through overview of the psychometric properties of this variable. The results reported here are comparable to the results obtained by Dobni (2008) if not better.

Table 5-9

EXPLORATORY FACTOR ANALYSIS AND RELIABILITY ANALYSIS

INNOVATION CULTURE

Scale Items		Factor Loadings	Item-Total Correlation
Innovation Culture			
ICL1		0.850	0.731
ICL2		0.798	0.663
ICL3		0.919	0.837
ICL4		0.903	0.811
Eigen Value	3.01		
Variance Explained	75.46%		
Cronbach's Alpha	0.890		

Capacity to Innovate (CAPI). The capacity to innovate construct was measured using a 4-item scale. As discussed in the previous chapter, this scale was newly developed for the purposes of this dissertation. The EFA provided a one principal component solution with an Eigen value of 2.98 that explained 74.62% of the total variance. Factor loadings for each item were above 0.86. The scale had good reliability as exhibited by an alpha of 0.88 and high item-to-total correlations (see Table 5-10 below).

Table 5-10

EXPLORATORY FACTOR ANALYSIS AND RELIABILITY ANALYSIS

CAPACITY TO INNOVATE

Scale Items		Factor Loadings	Item-Total Correlation
Capacity to Innovate			
CAPI1		0.871	0.765
CAPI2		0.865	0.757
CAPI3		0.900	0.805
CAPI4		0.819	0.680
Eigen Value	2.98		
Variance Explained	74.62%		
Cronbach's Alpha	0.883		

Decision-Making Comprehensiveness (DMC). A four item measure of decision-making comprehensiveness was adopted from the work of Slotegraaf and Atuahene-Gima (2011). The results reported here by way of the EFA and reliability analysis confirm the overall quality of the psychometric properties of this scale. One principal component was extracted with an Eigen value of 2.65 that explained 66.36% of the total variance. All factor loadings were above 0.75. Additionally, the scale had a coefficient alpha of 0.82 and good item-to-total correlations thereby confirming good reliability. Table 5-11 outlines the psychometric properties of the scale.

Table 5-11

EXPLORATORY FACTOR ANALYSIS AND RELIABILITY ANALYSIS

DECISION-MAKING COMPREHENSIVENESS

Scale Items		Factor Loadings	Item-Total Correlation
Decision-Making Comprehensiveness			
DMC1		0.763	0.591
DMC2		0.820	0.672
DMC3		0.832	0.676
DMC4		0.841	0.691
Eigen Value	2.65		
Variance Explained	66.36%		
Cronbach's Alpha	0.829		

Front-End of Innovation Performance (FPS and FPA). In Chapter IV I discussed the critical limitation of not having any extant scales that could be employed to measure the dependent variable of concern to this study. As a result, I proposed three different measures to ensure that I had the best possible chance to measure front-end of innovation performance. A 5-item subjective scale was developed in addition to a 5-item attribute based scale and a quantitative measure that is formative in nature and captures nominal type data. In terms of building the measurement model I focused on the two reflective measures, the subjective scale (FPS) and the attribute based scale (FPA).

The FPS scale showed extremely good psychometric properties and measurement quality as shown in Table 5-12. Upon running the EFA a one principal component solution was extracted with an Eigen value of 3.93 which explained 78.6% of the overall variance in the data. Each of the five items had factor loadings above 0.85 which is again first-rate. Reliability was also high based on Cronbach's alpha of 0.93 and item-to-total

correlations above 0.77. The findings here make a strong case for the further assessment of the subject front-end of innovation performance scale via CFA and ultimately in hypothesis testing.

Table 5-12

EXPLORATORY FACTOR ANALYSIS AND RELIABILITY ANALYSIS

FRONT-END OF INNOVATION PERFORMANCE (SUBJECTIVE)

Scale Items		Factor Loadings	Item-Total Correlation
Front-End of Innovation Performance (Subjective Version)			
FPS1		0.853	0.773
FPS2		0.899	0.837
FPS3		0.870	0.797
FPS4		0.919	0.867
FPS5		0.890	0.823
Eigen Value	3.93		
Variance Explained	78.60%		
Cronbach's Alpha	0.932		

Nevertheless, the same tests and analysis were run on FPA, the attribute based scale. Once again, as shown in Table 5-13, the results were promising. The EFA extracted one principal component with an Eigen value of 3.61 which explained 72.26% of the total variance. All five items had loadings above 0.72. Cronbach's alpha was 0.9 and item-to-total correlations were all acceptable.

Table 5-13

EXPLORATORY FACTOR ANALYSIS AND RELIABILITY ANALYSIS

FRONT-END OF INNOVATION PERFORMANCE (ATTRIBUTE)

Scale Items		Factor Loadings	Item-Total Correlation
Front-End of Innovation Performance (Attribute Version)			
FPA1		0.881	0.796
FPA2		0.863	0.773
FPA3		0.870	0.788
FPA4		0.722	0.602
FPA5		0.902	0.830
Eigen Value	3.61		
Variance Explained	72.26%		
Cronbach's Alpha	0.902		

Based on the results, there was a small likelihood that the results could be improved if FPA4 was dropped from the analysis. A second EFA and reliability analysis was performed on the FPA scale without FPA4. The EFA extracted one principal component with an Eigen value of 3.17 that explained 79.32% of the total variance. All factor loadings were above 0.85 this go around, and item-to-total correlations were 0.75 and above. A Cronbach's alpha of .913 was also an improvement over the previous run. The results were good enough to suggest that the FPA scale could be used in subsequent analysis if necessary. Section 5.4.3. discusses the dependent measure in more depth.

Ambiguity Aversion (AA). Ambiguity aversion was measured using a newly developed 5 item scale. As discussed previously in Chapter IV, there were no existing scales that I felt could adequately tap into the construct as defined in this dissertation. Of the five items, one of them was reverse coded. An initial EFA and reliability analysis showed a number of issues that needed to be resolved (Table 5-14). For instance, the

reverse coded item (AA3R) seemed to be creating considerable problems with the overall scale. Internal consistency reliability as examined by way of alpha was only 0.53, and the item-to-total correlation for AA3R was negative. Probably as a result of this, two principle components with Eigen values greater than 1were obtained when the EFA was run. The first principal component explained 41% of the variance while the second only explained 26% of the variance. At this point it was clear that the quality of the scale was below acceptable standards and had to be remedied.

Table 5-14

EXPLORATORY FACTOR ANALYSIS AND RELIABILITY ANALYSIS

AMBIGUITY AVERSION

Scale Items	Factor Loadings		Item-Total Correlation
Manager's Level of Ambiguity Aversion - *Initial Solution*			
	(1)	(2)	
AA1	0.751	-0.428	0.389
AA2	0.696	0.572	0.484
AA3 (Reversed)	-0.239	0.444	-0.115
AA4	0.711	-0.519	0.327
AA5	0.690	0.577	0.470
	(1)	(2)	
Eigen Value	2.08	1.30	
Variance Explained	41.75%	26.17%	
Cronbach's Alpha	0.532		

In order to obtain a better measure of ambiguity aversion, the reverse coded item was dropped to ascertain whether it would result in better scale properties. As shown in Table 5-15, doing this had a positive impact on the results of the EFA and the reliability analysis. While a two principal component solution was still obtained, a clearer picture emerged as to why this might be the case. It was apparent that AA2 and AA5 held

together to form one principal component while AA1 and AA4 represented the other principle component.

The first principle component (AA2 and AA5) explained 51.4% of the variance and had an Eigen value of 2.05, while the second principle component (AA1 and AA4) explained 31.15% of the total variance and had an Eigen value of 1.24. Upon analyzing the wording of the items, it made further sense as to why these results were obtained. The first principle component seemed to capture the extent to which managers felt threatened by ambiguity while the second component was tapping into a manager's preference for having odds to rely on. The EFA was rerun once again by employing Varimax rotation and this confirmed the observation (Table 5-15 reports these results). Upon assessing the bivariate correlation between AA14 and AA25, the two factors showed little in common (Pearson's $r = 0.206$, $p = 0.007$).

In order to proceed, the determination was made to adopt the first principle component (AA2 and AA5) to represent a manager's aversion to ambiguity. This decision was ultimately based on the fact that the two items that represent this principle component actually measured a manager's tendency to avoid having to deal with ambiguity. This is how the construct was conceptualized in the study. Nevertheless the second component was retained for further analysis to determine how it fit within a CFA and subsequently its impact on hypothesis testing.

Table 5-15

RERUN OF EXPLORATORY FACTOR ANALYSIS AND RELIABILITY ANALYSIS

AMBIGUITY AVERSION

Scale Items	Factor Loadings		Item-Total Correlation
Manager's Level of Ambiguity Aversion - *dropped AA3 (Reversed)*			
	(1)	(2)	
AA1	0.739	0.524	0.462
AA2	0.722	-0.553	0.506
AA4	0.691	0.596	0.413
AA5	0.716	-0.558	0.490
Manager's Level of Ambiguity Aversion - *with Varimax Rotation**			
	(1)	(2)	
AA1	0.156	0.893	
AA2	0.901	0.116	
AA4	0.071	0.909	*Rotation converged in 3 iterations
AA5	0.902	0.108	
	(1)	(2)	
Eigen Value	2.05	1.24	
Variance Explained	51.44%	31.15%	
Cronbach's Alpha	0.683		

In conclusion, the EFA and reliability analysis results ranged from reasonable to excellent. All reported Cronbach's alphas (except for ambiguity aversion) were above the 0.80 level, which meets the criteria set forth in prior literature for internal consistency reliability. The factor loadings reported in each of the EFAs were also high. Taken together, the results are strong enough to warrant moving towards building a full measurement model using CFA. The ambiguity aversion measure is further refined in this stage.

5.4.2. CFA and Construct Validity

The next step in assessing measurement quality was to run confirmatory factor analysis. As recommended by Churchill (1979) and Gerbing and Anderson (1988), a crucial step in assessing measurement quality is to determine unidimensionality, convergent validity, and discriminant validity. Unidimensionality is defined as "the existence of a single trait or construct underlying a set of measures," (Gerbing and Anderson 1988, p. 186). Churchill (1979, p.70) suggests that "evidence of the convergent validity of a measure is provided by the extent to which it correlates highly with other methods designed to measure the same construct." Discriminant validity is defined as "the extent to which the measure is indeed novel and not simply a reflection of some other variable," (Churchill 1979, p.70). In this dissertation, all CFA models were run in LISREL 8.80 (Jöreskog and Sörbom 1996).

As per the recommendation of multiple scholars, there are commonly accepted approached to tests for convergent validity and discriminant validity (cf. Hair, Black, Babin, and Anderson 2010; Fornell and Larcker 1981). The assessment of convergent validity is performed via a number of steps. First, all factor loadings should be above 0.5 and be statistically significant. Second, average variance extracted (AVE) should be greater than 0.5 for each variable. Following this, one should examine composite reliability (CR) and ensure that it is 0.7 or greater for each variable. Finally, CR should be greater than AVE to confirm convergent validity.

There are a number of ways to assess discriminant validity. In this dissertation, discriminant validity is determined by comparing AVE of any two constructs to the

squared multiple correlations between the two constructs. As suggested by Fornell and Larcker (1981), evidence of discriminant validity is obtained if the AVE for each factor is greater than the squared multiple correlation between those factors. One could also check to ensure that there aren't any significant cross-loadings, and/or also perform a χ^2 difference test between a two-factor model where the correlation between the factors is freely estimated and one where the correlation is constrained.

A sequence of CFAs was used to assess the quality of the measurement model. First a CFA model with just two factors was run. Then sequentially additional factors were added one at a time. As each factor was added, the fit statistics for the CFA model was assessed along with factor loadings before adding the next factor to the model. Ultimately, all seven factors of interest were included in the CFA and a reasonable measurement model was obtained. Below I discuss these steps in more detail.

The first two-factor CFA model included perceived competence (PCOMP) and fear of negative evaluation (FNE). Based on the EFAs that were run earlier, all 5-items for PCOMP and the 4-items for FNE were included. The model exhibited reasonable fit statistics with all indicators showing standardized loadings greater than 0.73 that were significant. Examining the modification indices suggested that model fit could be improved by allowing some of the error terms to correlate, however this is not theoretically justifiable. Therefore we proceeded with adding the next factor to the CFA.

Innovation Culture (ICL) was the next factor added to the model. Once again all factor loadings were above 0.71 and remained significant. Model fit statistics also improved marginally. Next I added capacity to innovate to the model. Again results

were good enough to continue building the measurement model. The next factor added was decision-making comprehensiveness (DMC). Certain issues emerged with the CFA at this stage. The first indicator for DMC exhibited a comparatively low standardized factor loading of 0.60. However model fit statistics showed some improvement compared to the previous CFA without the DMC factor. To ensure that there weren't any significant underlying problems before proceeding, I also checked the results of the EFA and item-to-total correlations from the previous sub-section for the DMC factor. The first indicator showed good item-to-total correlation in the previous stages of analysis. Based on this, I continued with the building of the measurement model.

Next I added the AA factor to the model. Recall that the EFA suggested major problem with the reverse coded 3rd item of AA. This item was subsequently dropped. Therefore in the CFA model, only four items belonging to the AA factor were included (AA1, AA2, AA4 and AA5). I also achieved a two-factor solution in the EFA which suggested that AA1 and AA4 held together while AA2 and AA5 formed the other factor. These issues required that I carefully run a series of CFAs to understand exactly how to proceed with the ambiguity aversion construct.

First I added the AA factor with all 4 indicators. This CFA model exhibited a number of critical issues. Primarily, the overall model fit statistics were extremely poor (χ^2 = 650.33, p = 0.00, df 260; GFI = 0.77; AGFI = 0.71; NFI = 0.89; NNFI = 0.92; CFI = 0.93; RMSEA = 0.094). As expected the factor loadings were problematic with AA1 and AA4 loading above 0.70 while AA2 and AA5 loading at 0.27 and 0.26 respectively on to the latent variable. Additionally the error term for AA1 was non significant (t (260) = 1.45, p = 0.14). It is clear that the measure need to be refined.

Looking back at the results of the EFA that was run earlier on the ambiguity aversion measure; while a two component solution was extracted, one component explained more than 50% of the total variance. This component comprised of AA2 and AA5. The second component which contained the other two AA items explained only 31% of the variance. Therefore I decided to rerun the CFA using only two indicators for the ambiguity aversion measure, AA2 and AA5. The ensuing results were noticeably better. The standardized loadings were significant and above 0.78. Model fit as examined via the fit indices were also better. Nevertheless, I also ran the CFA with AA1 and AA4 as the only indicators for ambiguity aversion. This model still had issues, for example the error term for AA4 was not significant (t (215) = 1.43, $p = 0.15$). As a result, the decision was made to proceed with AA2 and AA5 for now as the primary indicators for ambiguity aversion.

The final step in building measurement model was to include the dependent variable. Therefore the subjective front-end of innovation performance factor was added to the CFA. All five indicators were added. The resulting model showed good fit statistics ($\chi^2 = 680.59$, $p = 0.00$, df 329; GFI = 0.78; AGFI = 0.73; NFI = 0.93; NNFI = 0.95; CFI = 0.96; RMSEA = 0.07; SRMR = 0.058). All factor loadings were above 0.71 (except for DMC1 on DMC which as mentioned previously had a low standardized loading of 0.61) and significant at p = 0.01, Table 5-16 below provides a thorough overview of the results from the final CFA model.

Table 5-16

FULL MEASUREMENT MODEL (WITH FPS)

Construct	Standardized Loading	t-value*	Composite Reliability (CR)	Average Variance Extracted (AVE)
Perceived Competence (PCOMP)			0.943	0.768
PCOMP1	0.87	14.19		
PCOMP2	0.93	15.89		
PCOMP3	0.86	13.93		
PCOMP4	0.87	14.33		
PCOMP5	0.86	13.83		
Fear of Negative Evaluation (FNE)			0.923	0.753
FNE1	0.85	13.76		
FNE2	0.93	15.70		
FNE3	0.94	16.01		
FNE4	0.74	11.18		
Ambiguity Aversion (AA)			0.782	0.643
AA2	0.80	9.14		
AA5	0.80	9.15		
Innovation Culture (ICL)			0.897	0.688
ICL1	0.77	11.74		
ICL2	0.74	11.12		
ICL3	0.90	14.97		
ICL4	0.89	14.63		
Capacity to Innovate (CAPI)			0.886	0.660
CAPI1	0.79	12.00		
CAPI2	0.80	12.32		
CAPI3	0.87	14.07		
CAPI4	0.79	12.05		
Decision-Making Comprehensiveness (DMC)			0.800	0.502
DMC1	0.61	8.16		
DMC2	0.71	9.90		
DMC3	0.74	10.34		
DMC4	0.76	10.78		
Front-End Performance (FPS)			0.927	0.713
FPS1	0.79	12.13		
FPS2	0.85	13.53		
FPS3	0.83	13.17		
FPS4	0.90	15.10		
FPS5	0.86	13.83		

* all values significant at .01

Model Fit: χ^2 = 680.59; df = 329; p = 0.00; GFI = 0.78; NFI = 0.93; CFI = 0.96; RMSEA = 0.079; SRMR = 0.058

Once the final measurement model was obtained, I calculated composite reliability (CR) and AVE for each of the variables. As mentioned earlier, CR and AVE aids us in determining if we have convergent and discriminant validity. CR also provides support for the reliability of the measures. All the calculated CRs are above 0.78 which are high enough according to the recommended standards put forward by Fornell and Larcker (1981). AVE captures the extent of variance to measurement error in the scale. The AVE that was calculated for each factor is above 0.50 which meets the minimum acceptable standards put forth in the literature. Table 5-16 shows CR and AVE for each factor along with the results of the CFA.

Based on the criteria established earlier, the measurement model exhibits good convergent validity. All factor loadings are high and significant. For each factor CR is above 0.7 and AVE is above 0.5. Finally, CR is greater than AVE for each factor. Based on these results we can claim our measures have convergent validity.

The discriminant validity of a measure is examined with respect to any other scale in the model. Keep in mind that all calculated AVEs are above 0.50, which is good for discriminant validity to begin with. However discriminant validity was further examined by comparing AVE and squared multiple correlations for pairs of constructs. As mentioned earlier, if AVE is larger than the squared multiple correlations then we have evidence of discriminant validity (Fornell and Larcker 1981). A pairwise analysis of the measures shows that in all cases the AVE exceeded the square multiple correlations.

An additional test for discriminant validity is to perform a chi-square difference test between an iterative series of two-factor and one-factor models. Discriminant

validity is supported if the two-factor model is better than the corresponding one-factor model. This was the case when pairs of scales were put to this test thus providing further support for discriminant validity. Finally, based on the recommendations of Anderson and Gerbing (1988) and Bagozzi, Yi, and Phillips (1991), correlations lower the 1.0 test was performed between pairs of constructs. This is performed by comparing two two-factor models in LISREL; one model in which the correlation between latent variables is set to 1, and another in which the correlation is freely estimated. Since all correlations between pairs of constructs was less than 1, we find additional support for discriminant validity. Table 5-17 below outlines all the results of the discriminate tests that were performed.

Table 5-17

DISCRIMINANT VALIDITY ASSESSMENT

	AVE > SMC		$r_{xy} < 1$ test		2F vs. 1F test	
Construct Pairs	AVE	SMC	χ^2	*p* value	χ^2	*p* value
Perceived Competence (PCOMP) Fear of Negative Evaluation (FNE)	0.768 0.753	0.025	536.46(1)	0.000	536.46(1)	0.000
Decision-Making Comprehensiveness (DMC) Ambiguity Aversion (AA)	0.502 0.643	0.028	77.8(1)	0.000	237.83(1)	0.000
Capacity to Innovate (CAPI) Front-End Performance (FPS)	0.660 0.713	0.562	187.24(1)	0.000	187.24(1)	0.000
Decision-Making Comprehensiveness (DMC) Innovation Culture (ICL)	0.502 0.688	0.280	157.71(1)	0.000	157.71(1)	0.000

5.4.3. Dependent Variable

An important concern at this stage of the data analysis concerns the dependent variable. Prior to hypothesis testing, I had to choose between one of two scales employed to measure front-end of innovation performance. As discussed in Chapter IV, both scales were newly developed for the current study. The first was a subjective type of measurement based on the project manager's assessment of overall front-end results. We have referred to this scale as the subjective version (FPS). All the results presented hereto have included the FPS scale. The results of the EFA and consequent CFA suggest that we have a good measure of front-end performance in the FPS scale.

The second scale employed to measure front-end of innovation performance was based on a manager's evaluation of various activities (attributes) related to the front-end of innovation. This included subjective assessments of the sharpness of product definitions that emerged from the front-end, the percentage of ideas from the front-end that get funded etc. Due to the focus on various activities in the front-end of innovation, this scale is referred to as the attribute version (FPA). So far, the results of an EFA suggested that the FPA scale is a viable alternative to the FPS scale in terms of scale quality and could be used in subsequent analysis if necessary.

In order to further determine the measurement quality of the FPA scale, I built a measurement model including the 5-item FPA scale and performed a CFA. The procedures employed were exactly the same as with the CFA model that was presented in Table 5-16. The only difference, instead of entering the FPS scale as the last variable, I included FPA. Therefore just as with the previous CFA model, FPA was included once a

series of CFAs were conducted in building the measurement model via the sequential addition of other key variables in the study.

The initial results were problematic. Item 4 (FPA4) of the FPA scale had a low loading. The standardized coefficient for the FPA4 was below 0.50. As a result of this, the item was dropped and the CFA was rerun. Dropping the item with the low loading resulted in a much improved measurement model. The fit statistics were acceptable (χ^2 = 618.33, p = 0.00, df = 303; GFI = 0.79; AGFI = 0.74; NFI = 0.92; NNFI = 0.95; CFI = 0.96; RMSEA = 0.07; SRMR = 0.057). The four remaining items belonging to FPA all had standardized loadings of 0.78 and above. Table 5-18 on the next page provides the full results of the measurement model that includes the FPA measure

I also calculated AVE for the FPA scale and this was 0.715, well above the 0.50 threshold. Construct reliability for FPA was calculated to be 0.90 which is also well above acceptable levels. Based on the criteria explained earlier, the FPA measure exhibits good convergent validity. Discriminant validity was also examined. Once again I employed the three separate techniques employed earlier. All the analysis implied that the FPA scale exhibited good discriminant validity (see Table 5-19).

Table 5-19

DISCRIMINANT VALIDITY ASSESSMENT FOR FPA

	AVE > SMC		$r_{xy} < 1$ test		2F vs. 1F test	
Construct Pairs	AVE	SMC	χ^2	p value	χ^2	p value
Capacity to Innovate (CAPI) Front-End Performance (FPA)	0.660 0.715	0.435	276.15(1)	0.000	276.15(1)	0.000

Table 5-18

FULL MEASUREMENT MODEL (WITH FPA)

Construct	Standardized Loading	t-value*	Composite Reliability (CR)	Average Variance Extracted (AVE)
Perceived Competence (PCOMP)			0.943	0.768
PCOMP1	0.87	14.17		
PCOMP2	0.93	15.91		
PCOMP3	0.86	13.90		
PCOMP4	0.87	14.32		
PCOMP5	0.86	13.88		
Fear of Negative Evaluation (FNE)			0.923	0.751
FNE1	0.85	13.77		
FNE2	0.92	15.69		
FNE3	0.94	16.00		
FNE4	0.74	11.19		
Ambiguity Aversion (AA)			0.785	0.646
AA2	0.75	8.15		
AA5	0.85	8.84		
Innovation Culture (ICL)			0.896	0.685
ICL1	0.77	11.69		
ICL2	0.74	11.01		
ICL3	0.90	14.96		
ICL4	0.90	14.76		
Capacity to Innovate (CAPI)			0.886	0.662
CAPI1	0.77	11.70		
CAPI2	0.80	12.21		
CAPI3	0.89	14.41		
CAPI4	0.79	12.00		
Decision-Making Comprehensiveness (DMC)			0.800	0.502
DMC1	0.60	7.91		
DMC2	0.70	9.67		
DMC3	0.74	10.46		
DMC4	0.78	11.23		
Front-End Performance (FPA)			0.909	0.715
FPA1	0.87	13.95		
FPA2	0.83	13.06		
FPA3	0.78	11.91		
FPA5	0.90	14.79		

* all values significant at .01

Model Fit: $\chi^2 = 618.33$; df = 303; p = 0.00; GFI = 0.77; NFI = 0.92; CFI = 0.96; RMSEA = 0.078; SRMR = 0.057

In terms of the measurement model and fit statistics for the CFAs for FPS and FPA (see Tables 5-16 and 5-18), there is hardly any difference that would warrant the selection of one measure over the other. Both exhibit almost identical values in terms of measurement.

The next step in assessing the dependent measures involved correlating them with other performance measures that were included in the study. As suggested in both Chapters II and III, innovation being a sequential process, it is certain that success at the front end would correlate with success during later stages of innovation. Therefore, it is imperative to examine both newly created measures (FPS and FPA) against other latter stage performance measures. A number of established multi-item scales were used to measure success/performance in the latter stages of innovation. This included two 3-item scales that tapped into subjective evaluations of overall NPD success with regards to the firm's goals and overall NPD success with regards to the firm's goal but relative to its major competitors. In addition, two 2-item scales that evaluated the respondent's assessment of (i) the degree to which NPD (front-end of innovation) creates future opportunities and (ii) overall success of NPD (front-end of innovation) in management's opinion was also included.

Table 5-20 provides a correlation matrix of FPS and FPA respective to the other measures. The correlation with other performance measures is very similar between FPS and FPA. However, a closer look at the numbers reveals that FPS exhibits slightly higher correlations. Therefore, at this juncture, the dissertation adopts the FPS measure as the dependent variable for hypothesis testing. Nevertheless, a section on the results obtained using FPA as the dependent measure is provided later.

TABLE 5-20

CORRELATIONS, MEANS, STANDARD DEVIATIONS AMONG DEPENDENT MEASURES

Construct	FPS	FPA	NPDP1	FEIP	NPDP2	NPDP3
Front-End Performance - Subjective version (FPS)	0.93					
Front-End Performance - Attribute version (FPA)	.755**	0.90				
New-Product Development Performance - Version 1 (NPDP1)	.567**	.538**	0.83			
Front-End of Innovation Performance - 2 item scale (FEIP)	.534**	.486**	.777**	0.79		
New-Product Development Performance - Version 2 (NPDP2)	.615**	.631**	.652**	.637**	0.86	
New-Product Development Performance - Version 3 (NPDP3)	.562**	.532**	.638**	.625**	.764**	.91
Mean	4.87	4.96	5.01	5.01	4.90	4.80
Standard Deviation	1.02	1.06	1.19	1.11	1.07	1.15

** Correlation is significant at the 0.01 level (2-tailed).

NOTE: Numbers on the diagonal are Cronbach's alphas

5.4.4. Potential Measurement Issues

A concern with the measurement techniques used in the current study is common method variance. Common method variance arises from the use of perceptual measures, common raters, item context effects etc. (Podsakoff et al. 2003). The current study is comprised primarily of such measures. There have been a number of recommendations that have been put forth in order to reduce the potential impact of common method variance. A commonly followed strategy is to measure the dependent variable following the measurement of other variables of interest (Salancik and Pfeffer 1977). The items in the current study were organized with this recommendation in mind. The dependent variable FPS is measured after other variables like FNE, PCOMP, AA, ICL, CAPI, and DMC.

In order to test the extent to which the data has been corrupted due to common method variance, an empirical test can be conducted. This test involves subjecting all the items related to the key variables in the model to a factor analysis. If the results of the factor analysis suggest a significantly lower number of factors then the theoretical framework suggests, then this may suggest a common method variance problem (Harman 1967; Podsakoff and Organ 1986). An exploratory factor analysis was run which included all 28 items that reflected the 7 latent variables. The results of the EFA showed a five-factor solution that explained 73.08% of the total variance. When an additional sixth factor with an Eigen value of 0.988 was included, the total variance explained was 76.6%. While the theoretical framework suggests there should be 7 factors, the exploratory factor solution obtained 5/6 factors, which is not significantly lower than

what is theorized. Therefore we have empirical evidence that suggests that we do not have a common method variance problem.

5.4.5. Summated Scale Descriptives

Based on the results obtained in the previous stages of analysis, the items for each variable were finalized. Summated scales for each construct were then constructed. Since this dissertation employs only reflective measures, the procedure was straightforward. For each construct, the selected items were summated and the score was then divided by the number of items. In other words, for each construct I averaged the scores of the underlying items to arrive at the summated scale. All hypothesis testing employed the use of these summated scales.

Table 5-21 below provides the correlation matrix for the variables employed in hypothesis testing. The diagonal represents Cronbach's alpha that was obtained during the EFA stage. A review of the correlations shows that a majority of the variables correlate with others at significant levels. Exceptions to this are the FNE and AA constructs. Both constructs show a limited degree of correlation with other study variables as shown by the low and non-significant correlation values. Nevertheless, the correlation matrix does not include any unexpected values either in terms of magnitude or polarity.

Finally, the Table also includes all means and standard deviations for each of the seven study variables. There are no formative variables employed in hypothesis testing.

TABLE 5-21

CORRELATIONS, MEANS, STANDARD DEVIATIONS AMONG STUDY VARIABLES

Construct	PCOMP	FNE	AA	ICL	CAPI	DMC	FPS
Perceived Competence (PCOMP)	.95						
Fear of Negative Evaluation (FNE)	-.177*	.92					
Ambiguity Aversion (AA)	-.160*	.398**	.78				
Innovation Culture (ICL)	.380**	-0.059	-0.101	.89			
Capacity to Innovate (CAPI)	.258**	-0.103	-0.064	.743**	.88		
Decision-Making Comprehensiveness (DMC)	.367**	-.209**	-0.128[Z]	.455**	.477**	.82	
Front-End Performance (FPS)	.386**	-0.104	0.034	.668**	.691**	.519**	.93
Mean	5.50	2.56	3.21	4.94	4.98	5.17	4.87
Standard Deviation	1.16	1.39	1.46	1.19	1.17	0.90	1.02

[Z] Correlation is significant at the 0.10 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

NOTE: Numbers on the diagonal are Cronbach's alphas

5.5. Hypothesis Testing

The following section presents and discusses the results of the hypothesis testing that was employed in the study. Hypothesis testing was performed by fitting simultaneous multiple regression equations in a hierarchical manner. Appendix B outlines each of the relevant regression equations. These equations were constructed based on the conceptual model that was presented earlier. The only endogenous variable in the study is FPS, while all other remaining variables are exogenous. All hypothesis testing was performed in SAS 9.3 using the PROC SYSLIN procedure. This allows us to employ three stage least squares (3SLS) estimation which allows simultaneous estimation of equations.

This section also outlines various mediation tests that were performed to further analyze the relationships posited by the conceptual model. I also present a detailed discussion on the role of control variables in the study and accordingly present alternative models that help explain the data. Finally, I review the testing of basic regression assumptions as outlined by Hair et al. (2010).

5.5.1. Results of Initial Hypothesis Testing

Since the conceptual model in the current study is not overly complicated, hypothesis testing was done in two stages. First I ran a main effects model and then I added the interaction effects and ran a second model that then included all the relationships of interest. However, at a latter stage I will offer alternative models that could potentially have import.

The main effects model included all the direct effects suggested by the conceptual model. In other words, the interaction terms that represent the suggested moderation were not included. As such, four equations were specified in the PROC SYSLIN procedure. The first equation regressed the dependent variable FPS on to CAPI and DMC. The second equation regressed CAPI with ICL as the predictor, while the third equation regressed DMC on to AA. The final equation modeled the effect of FNE and PCOMP on AA. As stated previously, since we are employing 3SLS, all estimations are performed simultaneously.

Table 5-22

3SLS RESULTS FOR MAIN EFFECTS MODEL

Equation	β	Std. Coefficient	t-value	*p* value	Hypothesis
Dependent Variable: FPS					
Intercept	0.786	0.0	2.44	0.015	
DMC	0.205	0.183	3.13	0.002	H6
CAPI	0.605	0.693	11.77	<.0001	H8
Dependent Variable: CAPI					
Intercept	1.493	0.0	6.2	<.0001	
ICL	0.707	0.721	14.95	<.0001	H7
Dependent Variable: DMC					
Intercept	5.555	0.0	33.66	<.0001	
AA	-0.119	-0.192	-2.57	0.011	H5
Dependent Variable: AA					
Intercept	3.187	0.0	5.71	<.0001	
PCOMP	-0.179	-0.143	-2.04	0.043	H2
FNE	0.399	0.381	5.42	<.0001	H1

System Weighted MSE = 0.91
Degrees of Freedom = 666
System Weighted R-Square = 0.476

As shown in Table 5-22 above, the results of the main effects model are promising. All the hypothesized main effects were significant and in the specified direction. Both DMC and CAPI had a strong and significant impact on FPS. ICL was a significant predictor of CAPI. Earlier we had hypothesized a significant negative effect of ambiguity aversion on decision-making comprehensiveness, the main effects model supported this. Finally, both PCOMP and FNE had a significant effect on AA in the direction hypothesized.

Nonetheless, while the results from this model support all the direct effect hypotheses that were proposed, a more robust examination would be to include the proposed interactions as well. This was done in the second model and the subsequent results are interesting.

Before adding the interaction terms to build the full model, an analysis was performed to assess the degree of multi-collinearity. Multi-collinearity is a concern when assessing moderation in regression using cross-product terms. Examining the correlation between a cross-product term and the variables used to make that cross product term can be used to easily identify multi-collinearity. Cross-product terms were created by multiplying the scores for PCOMP and ICL (PXI), and FNE and ICL (FXI). As expected, the correlations between the cross-product term (PXI and FXI) and underlying variables (PCOMP and ICL; FNE and ICL respectively) were rather high. For example PXI was correlated with PCOMP at .775 (p = .000) and ICL at .864 (p = .000). This suggested that multi-collinearity was indeed a problem.

This can be remedied by mean-centering the variables before creating the cross-product terms. As such, PCOMP, FNE, and ICL were mean-centered by subtracting the grand mean from each score. These mean centered scores were then used to create the new cross-product terms PXIc and FXIc. Once again correlations between PXIc (FXIc) and PCOMP (FNE) and ICL were examined. The correlations were much lower as a result of the mean-centering procedure employed, suggesting that multi-collinearity was no longer an issue (*for comparison:* PXIc was correlated to PCOMP at -.217, $p = .000$ and ICL at .042, $p = .000$). It should be noted that Echambadi and Hess (2007) show that a mean-centering approach is not always advantageous in alleviating collinearity issues in moderated multiple regression. However, we adopted the mean-centered variables due to the reported reduction in the correlations between the variables.

Table 5-23 below outlines the results from subjecting the full model to 3SLS estimation. This model differs from the previous run in that the interaction terms are now included in the final equation. This full model gives us the required information to make a decision in regards to the eight hypotheses that were outlined in the previous chapter. I discuss whether or not they receive support starting with H1.

Hypothesis 1 and 2. The first two hypotheses dealt with the main effect of FNE and PCOMP on ambiguity aversion. Specifically, H1 suggested that FNE would have a positive effect on AA, while H2 proposed that PCOMP would have a significant negative effect on AA. The results provide support for H1. FNE is a significant predictor of ambiguity aversion such that when a manger experiences high fear of negative evaluation, her/his aversion to ambiguity is higher ($\beta = 0.392$, $p < 0.0001$). However, I do not find support for H2. The results show a non-significant effect of perceived

competence on ambiguity aversion (β = -0.092, p = 0.344). Nevertheless, the direction of the relationship is as conceptualized, suggesting that a manager with higher perceived competence may be utilizing that advantage to mitigate his aversion to ambiguity rather than enhancing it. This conclusion is further strengthened based on the results provided by the main effects model where the relationship is both negative and significant.

Table 5-23

3SLS RESULTS FOR FULL MODEL

Equation	β	Std. Coefficient	t-value	p value	Hypothesis
Dependent Variable: FPS					
Intercept	0.815	0.0	2.51	0.012	
DMC	0.206	0.184	3.13	0.002	H6
CAPI	0.598	0.684	11.52	<.0001	H8
Dependent Variable: CAPI					
Intercept	1.507	0.0	6.3	<.0001	
ICL	0.704	0.718	14.87	<.0001	H7
Dependent Variable: DMC					
Intercept	5.512	0.0	33.36	<.0001	
AA	-0.106	-0.171	-2.28	0.023	H5
Dependent Variable: AA					
Intercept	3.159	0.0	29.10	<.0001	
PCOMP	-0.092	-0.074	-0.95	0.344	H2
FNE	0.392	0.375	5.23	<.0001	H1
ICL	-0.090	-0.073	-0.95	0.342	
PCOMP x ICL (PXIc)	0.133	0.139	1.92	0.056	H4
FNE x ICL (FXIc)	0.052	0.056	0.77	0.440	H3

System Weighted MSE = 0.992
Degrees of Freedom = 663
System Weighted R-Square = 0.472

Hypothesis 3 and 4. The moderation hypotheses suggested that innovation culture would moderate the relationship between PCOMP and AA, and between FNE and AA.

Hypothesis 3 states "when innovation culture is weak, there is no clear relationship between fear of negative evaluation and ambiguity aversion (although ambiguity aversion should be high), on the other hand when innovation culture is strong, there is strong positive relationship between fear of negative evaluation and ambiguity aversion." The results outlined in Table 5-23 provide no support for H3. Assessing the coefficients associated with the interaction term between FNE and ICL (FXIc) helps determine if we have support for H3. The effect of FXIc on ambiguity aversion is not significant (β = 0.052, p = 0.440).

Hypothesis 4 states, "when innovation culture is weak, there is no clear relationship between sense of competence and ambiguity aversion (although ambiguity aversion should be high). On the other hand when innovation culture is strong, there is a strong negative relationship between sense of competence and ambiguity aversion." The results provide partial support for H4. Looking at the coefficients reported in Table 5-23, the interaction term between perceived competence and innovation culture (PXIc) has a marginally significant effect on ambiguity aversion (β = 0.133, p = 0.056). I refer to this as being a marginally significant effect because p value is barely above 0.05. Some researchers may choose to consider this result marginally significant. However, as will be discussed later, the inclusion of covariates in the model has serves to drastically improve this relationship.

Hypothesis 5. In the conceptual model, I suggested that ambiguity aversion has a negative effect on front-end of innovation performance due to the suppression effect of decision-making comprehensiveness. As such, H5 suggested a negative effect of AA on DMC such that when ambiguity aversion is high it serves to reduce decision-making

comprehensiveness. The results outlined in Table 5-23 provide support for this hypothesis. Ambiguity aversion has a significant negative effect on DMC ($\beta = -0.106$, $p = 0.023$). This might suggest that project teams do pick up on whether or not their project leaders are averse to ambiguity. Specifically supporting the notion that decision-making comprehensiveness reduces if a project manger is averse to ambiguity. Thus implying that concepts or ideas with merit, but associated with ambiguous probabilities, might be discarded since teams have little confidence that their managers will give such concepts and ideas a fair chance.

Hypothesis 7. The conceptual model suggests a previously widely tested and supported relationship between innovation culture and a firm's capacity to innovate. Specifically, H7 suggests that ICL has a positive effect on CAPI. The results, in keeping with prior research, provide support for H7. Innovation culture has a positive and significant effect on capacity to innovate ($\beta = 0.704$, $p < 0.0001$).

Hypothesis 6 and 8. Front-end of innovation performance is the dependent variable in the current study as measured via the FPS scale. The conceptual model outlines two separate predictors of FPS, decision-making comprehensiveness and capacity to innovate. Hypothesis 6 proposes a positive relationship between DMC and FPS. The results reported in Table 5-23 provide support for this Hypothesis. Decision-making comprehensiveness has a positive significant impact on front-end of innovation performance ($\beta = 0.206$, $p = 0.002$).

Extant literature has shown that capacity to innovate has a positive effect on firm performance. However, no previous study has examined whether this relationship would

hold with performance at the front-end of innovation. Hypothesis 8 proposes a positive relationship between capacity to innovate and front-end of innovation performance. The data and subsequent analysis provide strong support for this hypothesis. The results reported in Table 5-23 shows that CAPI has a significant positive effect on FPS (β = 0.598, $p < 0.0001$). Based on the reported parameter coefficients obtained via hierarchical regression using 3SLS, we have two significant predictors of FPS.

5.5.2. Control Variables and Alternative Models

While the results of the full model are so far promising, there remains the possibility that the reported relationships might vary based on the inclusion of control variables in the 3SLS estimation model. As pointed out in Chapter IV, a number of control variables were included in the study design. This was done to control for unplanned extraneous effects that could potentially have an impact on hypothesis testing. Apart from firm characteristic measures and items intended to tap managerial experience and competence, the other key control variables included those used to measure environmental factors. This included scales for market turbulence, technological turbulence and environmental uncertainty. The justification for the inclusion of these measures is provided in the previous chapter. To determine if the control variables had any impact on the study, I first examined the correlations between study variables and control variables. Table 5-24 below shows these correlations.

Generally, a significant correlation between a study variable and a control variable suggests that it might have to be controlled for in any regression equation that includes the correlated study variable.

TABLE 5-24

CORRELATIONS BETWEEN STUDY VARIABLES AND CONTROL VARIABLES

Control Variables	Study Variables							
	PCOMP	FNE	AA	DMC	ICL	CAPI	FPS	FPA
Market Turbulence (summated)	.345**	0.089	0.077	.270**	.406**	.362**	.330**	.284**
Technological Turbulence (summated)	0.137	-0.066	-0.129	.337**	.288**	.326**	.244**	.251**
Environmental Uncertainty (summated)	-0.137	-0.127	-0.099	-0.079	-0.138	-.150*	-.316**	-.250**
Innovation Team Size	0.058	0.128	0.133	0.043	0.063	-0.025	0.033	0.068
Years in industry	.270**	-.213**	-.154*	0.079	-0.01	0.012	0.051	0.015
Years with current firm	0.086	-0.136	-0.082	-0.048	-0.097	-0.104	-0.044	-0.009
Years of innovation experience (whole career)	.332**	-.315**	-.270**	.174*	0.086	0.103	0.101	0.136
Years of innovation experience (with current firm)	.170*	-.181*	-0.126	0.001	-0.036	0.005	0.031	0.077
Firm size by annual sales	0.101	0.044	-0.022	0.039	-0.019	-.233**	-0.102	-0.072
Firm size by number of employees	0.05	0.065	0.044	0.014	-0.043	-.267**	-0.113	-0.055

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

A couple of things stand out when looking at Table 5-24. First, it is apparent that the environmental conditions measures are significantly correlated with the dependent variable (both FPS and FPA). These environmental factors include market turbulence, technological turbulence, and environmental uncertainty. These well-established scales were purposely included in the study, as previous studies have frequently found that they play an explanatory role in models that examine firm performance, innovation, and other general models in marketing strategy (e.g. Marketing Orientation etc.). Understandably, the same three scales also are significantly correlated with CAPI, ICL, and DMC. Therefore any alternative models will have to examine the role of these three variables.

The next set of control variables that warrant further examination include measures related to a manager's experience. Both in terms of overall experience and experience specifically related to innovation activities. These two measures are significantly correlated with PCOMP, FNE, and AA. This is a logical finding. As managers become more experienced, they are likely to perceive more competence in their decision-making abilities compared to an individual with limited years of experience. Similarly, managers might experience less fear of negative evaluation and aversion to ambiguity as they gain more experience. Including these two measures as covariates may have an impact on the results of the prior hypothesis testing.

To further examine these relationships (including others that were flagged significant) I included these control variables in relevant regression equations both together and separately. Several models were examined, some that treated the control variables as covariates and others that examined them as moderators. I also examined the impact of entering the control variables in various sequences. At all stages I examined

the impact on R-square and whether there was a significant increase in R-square. This was done to determine if the new model explained the data better than previous models. This approach is a useful method of examining the veracity of the regression model because R-square is essentially the percent of variance in the dependent variable that is explained by the all the independent variables in the model.

Ultimately, after running a series of hierarchical regression models using 3SLS estimation, I arrived at one model that had a positive impact on the previous full model outlined in the initial hypothesis testing section. The inclusion of 'years of innovation experience (during one's whole career)' measure (YT3) as a covariate on ambiguity aversion served to have a positive impact on H4. Hypothesis 4 proposed an interaction effect between ICL and PCOMP on ambiguity aversion. The earlier results were deemed marginally significant since the *p* value was slightly above 0.05. As can be seen from Table 5-25, adding the significant YT3 control variable serves to strengthen the significance of the PXIc interaction term ($p = 0.028$). Inclusion of this control variable also had a small positive impact on system weighted R-square. I tested to see if the control variable moderated the relationship between FNE and AA, and PCOMP and AA rather than having a direct effect on AA. The results clearly showed no moderation effect of YT3 on the main effect of FNE and PCOMP on AA. As such, YT3 was included in the model as a direct covariate on AA.

As for other covariates, none served to have a significant impact that warranted their ultimate inclusion in the final model. For example, while market turbulence, technological turbulence, and environmental uncertainty show significant correlations with other variables, their inclusion in various combinations into regression models

yielded no change in the previous results of hypotheses testing. Therefore, in an effort to retain a parsimonious model, these variables were not included. So in summary, only one control variable was added to the full model discussed previously.

Table 5-25

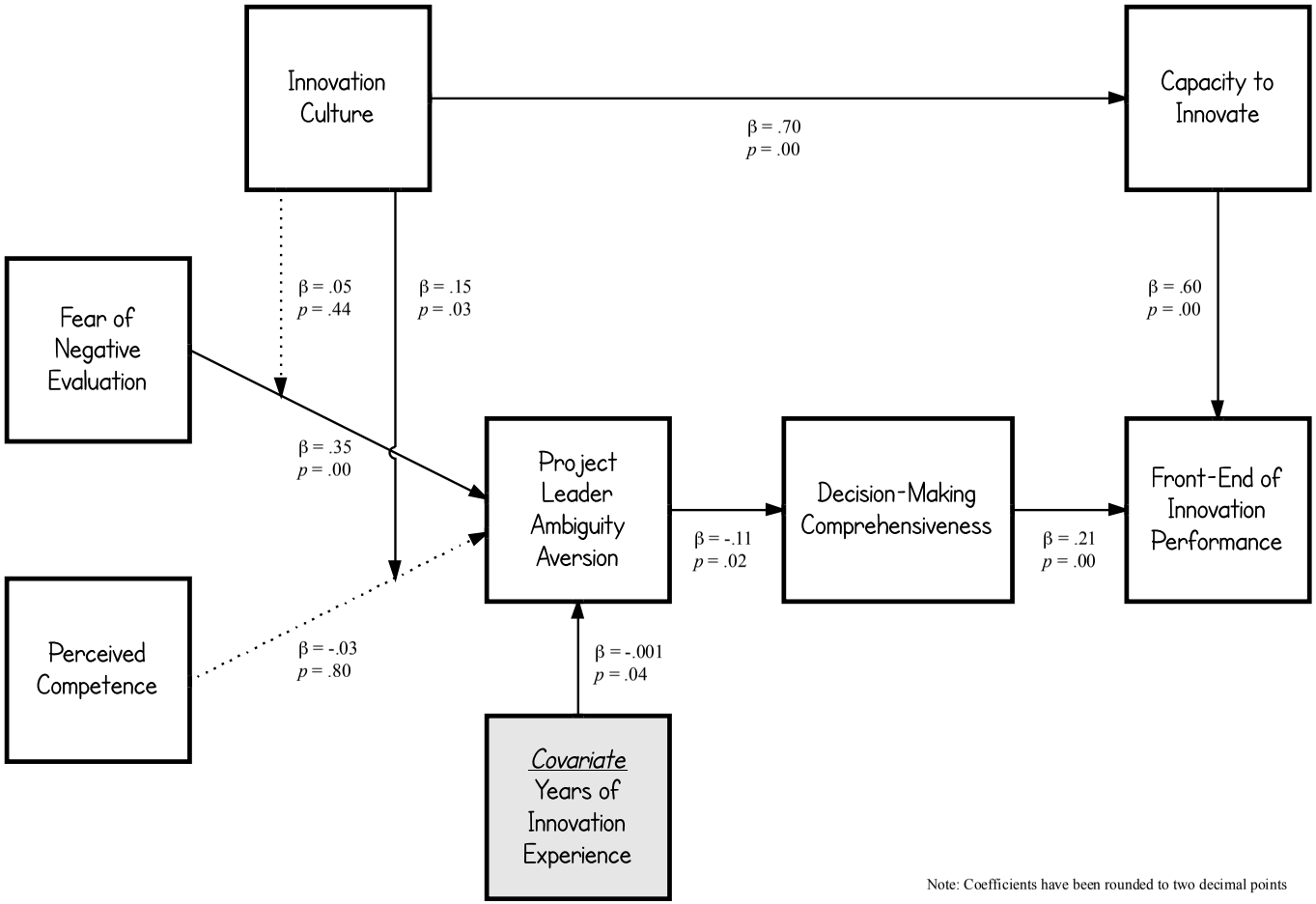
3SLS RESULTS FOR FULL MODEL WITH COVARIATES ADDED

Equation	β	Std. Coefficient	t-value	*p* value	Hypothesis
Dependent Variable: FPS					
Intercept	0.816	0.0	2.52	0.012	
DMC	0.206	0.183	3.12	0.002	H6
CAPI	0.598	0.685	11.52	<.0001	H8
Dependent Variable: CAPI					
Intercept	1.507	0.0	6.26	<.0001	
ICL	0.704	0.718	14.87	<.0001	H7
Dependent Variable: DMC					
Intercept	5.511	0.0	33.35	<.0001	
AA	-0.105	-0.170	-2.27	0.024	H5
Dependent Variable: AA					
Intercept	3.460	0.0	18.97	<.0001	
PCOMP	-0.025	-0.020	-0.25	0.804	H2
FNE	0.350	0.334	4.54	<.0001	H1
ICL	-0.097	-0.079	-1.03	0.302	
PCOMP x ICL (PXIc)	0.153	0.160	2.22	0.028	H4
FNE x ICL (FXIc)	0.051	0.055	0.77	0.442	H3
Covariate: YT3	-0.001	0.156	2.05	0.042	

System Weighted MSE = 0.992
Degrees of Freedom = 662
System Weighted R-Square = 0.474
NOTE: The covariate YT3 refers to the number of years of innovation experience during whole career.

Based on these results, the conceptual model can be presented with the appropriate path coefficients as well as demonstrating significant and non significant paths. This is shown in Figure 5-1 below.

FIGURE 5-1 – CONCEPTUAL MODEL WITH PATH COEFFICIENTS



5.5.3. Moderation Tests and Simple Slopes

Since we have two hypotheses that suggested moderation effects, it is often useful to examine the simple slopes to gain a better understanding of the relationships (Cohen and Cohen 1983). As shown in Figure 5-2, the interaction of FNE and ICL on AA (H3) is not significant, while the interaction of PCOMP and ICL on AA is significant.

Figure 5-2 – Simple Slope Analysis of H3

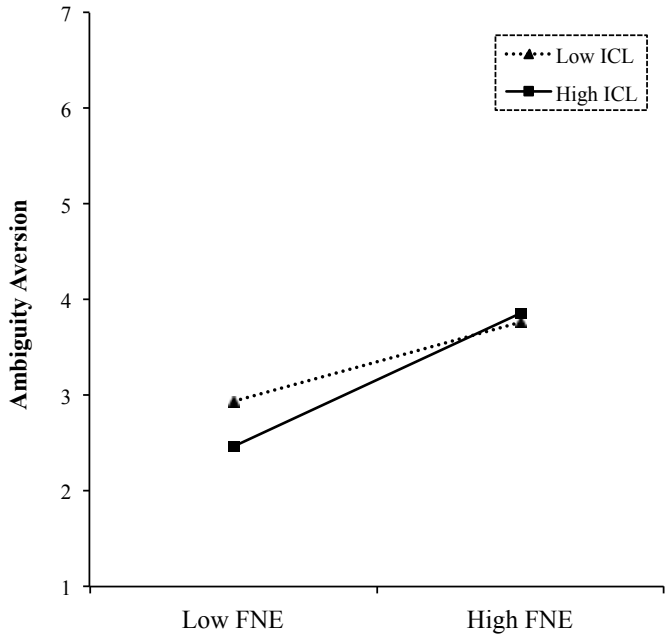
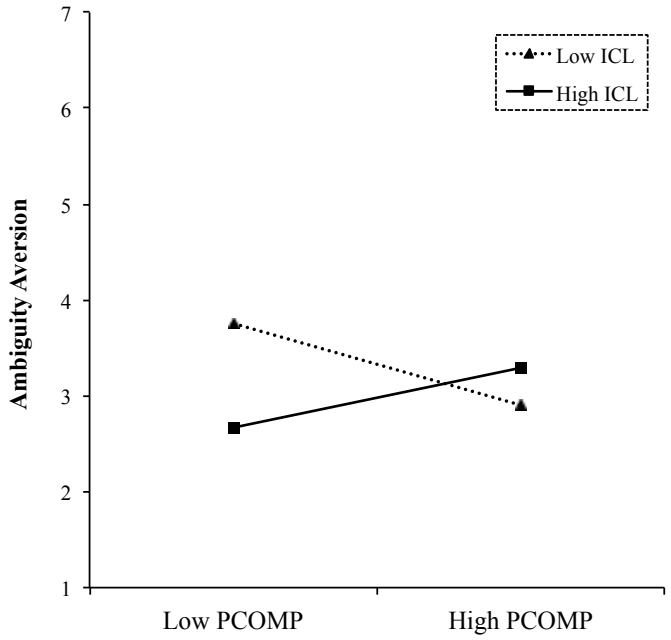


Figure 5-2 above shows the simple slope that graphically depicts the interaction of FNE and ICL on AA. It suggests that the level of innovation culture has very limited bearing on the relationship between FNE and AA. This unexpected result might be explained due to the strong main effect of fear of negative evaluation on ambiguity aversion. Originally, the conceptualization suggested the degree of innovation culture,

especially when low would have no bearing on ambiguity aversion (see Figure 3-2, p. 80). Even with the inclusion of the additional covariate in the final model, the relationship between fear of negative evaluation and ambiguity aversion remains very strong, and this shows up in the simple slope diagram.

Figure 5-3 – Simple Slope Analysis of H4



Examining the simple slope diagrams also provides further insight into the relationship between the interaction of innovation culture and perceived competence on ambiguity aversion. Figure 5-3 above graphically shows the simple slope for the respective interaction effect. The diagram is quite different from that proposed in Figure 3-3 in Chapter III. The low innovation culture line shows a negative slope while the high innovation culture line suggests a positive relationship between PCOMP and AA. Even

though the interaction is significant, the slopes suggest an almost opposite relationship from that hypothesized.

A further effort to test for moderation was performed in SAS 9.3 using the PROCESS macro and the guidelines provided by Preacher and Hayes (2012). This macro employs the use of either ordinary least squares or logistic regression to provide parameter estimates in path analytic frameworks that include various types of mediation and/or moderation. This process also employs bootstrapping methods to provide estimates for indirect effects.

According to the specified guidelines, I ran a Preacher and Hayes Model 7 (see Appendix D, p. 237) to test for the moderation effects suggested in H3 and H4. Model 7 tests the interaction of ICL on the relationship between FNE (PCOMP) and AA while also accounting for the mediation relationship of FNE (PCOMP) to AA to DMC. Appendix C provides further details on how PROCESS was used in this dissertation to test for moderation. The results were somewhat mixed, the analysis using the Preacher and Hayes method found no support for the proposed moderation effect of ICL on the relationship between FNE and AA. Surprisingly, it also did not find a significant moderation of ICL on the PCOMP to AA path. Overall the results of the Preacher and Hayes test for moderation are somewhat contradictory to the results of the hierarchical regression analysis using 3SLS reported above.

Based on the three moderation tests, all three soundly reject H3. There is no interaction between ICL and FNE on ambiguity aversion. However, in regards to H4, the results of the hierarchical regression provide support for the interaction term, the simple

slope analysis is opposite from what was proposed, and the Preacher and Hayes test for moderation provided no support for the moderation. The results here clearly necessitate further examination.

Table 5-26

RESULTS OF HYPOTHESIS TESTING

Hypothesis	Statement	Result
H1	When fear of negative evaluation is high, the project leader experiences a significantly higher level of ambiguity aversion compared to when fear of negative evaluation is low.	Supported
H2	A project leader's perceived competence over the decision domain is significantly related to his/her level of ambiguity aversion, such that when perceived competence is high, ambiguity aversion is low and vice versa.	Supported in main effect model
H3	When innovation culture is weak, there is no clear relationship between fear of negative evaluation and ambiguity aversion (although ambiguity aversion should be high), on the other hand when innovation culture is strong, there is strong positive relationship between fear of negative evaluation and ambiguity aversion.	Not Supported
H4	When innovation culture is weak, there is no clear relationship between sense of competence and ambiguity aversion (although ambiguity aversion should be high. On the other hand when innovation culture is strong, there is a strong negative relationship between sense of competence and ambiguity aversion	Uncertain, but interaction term is significant
H5	The relationship between ambiguity aversion and decision making comprehensiveness is negative.	Supported
H6	The relationship between decision making comprehensiveness and front-end of innovation performance is positive	Supported
H7	The relationship between Innovation Culture and Capacity to Innovate is positive	Supported
H8	The relationship between Capacity to Innovate and Front-End of Innovation Performance is positive	Supported

A summary of the results of the hypothesis testing is provided in Table 5-26 below. These results are based on the hierarchical regressions performed on the final model (including the covariates) using 3SLS estimation. Overall I found support for H1,

H2, H5, H6, H7, and H8. Hypothesis 3 is rejected while the support for H4 is inconclusive.

5.5.4. Mediation Tests

The conceptual model proposed in this dissertation consists of a number of relationships that are mediated. For example, the effect of ambiguity aversion on front-end of innovation performance is mediated by decision-making comprehensiveness. There are three other instance where mediation is present, (a) ICL → CAPI → FPS, (b) PCOMP → AA → DMC, and (c) FNE → AA → DMC.

Mediation was assessed using two approaches. First all mediation tests were performed using the procedures outlined by Baron and Kenny (1986). According to Baron and Kenny (1986), to test for mediation one needs to run three separate regression equations. This is done to determine (a) that the independent variable has an effect on the dependent variable, (b) to show that the independent variable has an effect on the mediator, (c) to determine the effect of the mediator on the dependent variable, and (d) to determine the effect of the independent variable on the dependent variable while controlling for the mediator. This is then followed by a Sobel test (to assess the significance of the indirect path of the independent variable on the dependent variable). Using the Baron and Kenny steps I found support for only one mediation path, that from ICL to FPS through CAPI. None of the other three possible mediations were supported.

The second approach for analyzing mediation is based on the recommendations of Zhao, Lynch, and Chen (2010) who recommend testing for mediation using bootstrapping methods proposed by Preacher and Hayes (2004). This procedure involves

running either the INDIRECT macro (also known as the Preacher and Hayes script) or the PROCESS macro in either SPSS or SAS. The bootstrapping method employs non-parametric tests to provide 95% confidence intervals for the significance of the indirect path (*ab*) from the independent variable to the dependent variable through the mediator. If the 95% confidence intervals obtained from the bootstrap results do not include zero then we have evidence of mediation. Zhao, Lynch, and Chen (2010) also provide a decision tree to further evaluate the relationship that is obtained based on the results. The decision tree includes three types of mediation (complementary, competitive, and indirect-only) and two types of non mediation (direct-only and no-effect) to help classify the type or relationship (Zhao, Lynch, and Chen 2010).

I executed and ran the INDIRECT computational macro in SPSS 21 for Mac to obtain the results of the mediation test based on the bootstrapping method. The results support a complementary mediation for ICL → CAPI → FPS. A no-effect, non mediation was the results for the test on the AA → DMC → FPS path. The final two tests of the mediation of AA between PCOMP and DMC as well as FNE and DMC were classified as direct-only, non mediation based on the decision tree. All mediation test results are reported in Table 5-27.

There are a number of problematic takeaways based on the mediation tests. For example, the no-effect, non mediation suggested for the AA → DMC → FPS path is an issue. On further examination, it is abundantly clear that ambiguity aversion was not having the intended effect on mediation as suggested in the conceptual model. All mediation paths that included the AA variable were classified as non mediations.

TABLE 5-27

MEDIATION TEST RESULTS

Mediation Relationship	Path Coefficient				95% Bootstrap Confidence Interval		Preacher and Hayes Model Number	Mediation Result		
	a	b	c'	ab	LL	UL		Baron and Kenny Result	Preacher and Hayes Result	Zhao, Lynch, and Chen Classification
IV = PCOMP, MED = AA, DV = DMC	-0.200*	-0.044	0.277**	0.009	-0.006	0.041	4	No	No	Direct-only, non mediation
IV = FNE, MED = AA, DV = DMC	0.418**	-0.033	-0.123*	-0.014	-0.061	0.025	4	No	No	Direct-only, non mediation
IV = AA, MED = DMC, DV = FPS	-0.080	0.600**	0.072	0.048	-0.113	0.008	4	No	No	No effect, non mediation
IV = ICL, MED = CAPI, DV = FPS	0.725**	0.380**	0.295**	0.276**	0.175	0.407	4	Yes	Yes	Complementary, mediation
Mediation tests for revised model										
IV = PCOMP, MED = DMC, DV = FPS	0.460**	0.292**	0.305**	0.135**	0.023	0.267	4	Yes	Yes	Complementary, mediation
IV = FNE, MED = DMC, DV = FPS	0.460**	-0.326*	0.009	-0.150*	-0.314	-0.034	4	Yes	Yes	Indirect-only, mediation

Explanation of regression paths:

$MED = i_i + a_i(IV) + e_i$ Direct effect of IV on MED = a

$DV = i_i + c'_i(IV) + b_i(MED) + e_i$ Direct effect of MED on DV = b

Direct effect of IV on DV = c'

Indirect effect of IV on DV through MED = ab

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Due to the problems associated with ambiguity aversion, I decided to test the relevant mediation paths without AA in the model. The results were startling. Omitting AA from the model resulted in strong support for mediation between FNE (and PCOMP) to FPS through DMC. These results are also reported in Table 5-27. This outcome required that I suggest revisions to the conceptual model based on the mediation analysis.

5.5.5. Suggested Revisions to the Model

It is clear from the mediation tests that ambiguity aversion plays a very limited, if not irrelevant role, in the conceptual model. Looking back at the correlations amongst study variables in Table 5-21 (p. 152), the AA variable is not significantly correlated with any other key variable in the study. At this point it is clear that the ambiguity aversion is not a good fit in the model. There existed other cues on the issues regarding ambiguity aversion. For example, the simple slopes for the proposed interactions discussed previously were puzzling due to their unexpected slopes, and the Preacher and Hayes moderation tests were all non significant. I also examined regressing DMC on not just AA, but also on PCOMP, FNE, ICL, PXIc and FXIc. The subsequent results clearly indicate that AA is not a good predictor of DMC as the associated parameter was both non significant and negligible. On the other hand, the newly added terms were all significantly related to DMC.

Therefore, I decided to rerun all relevant analysis without ambiguity aversion in the model. The expectation now was that, based on the data at hand, a better model could be offered. A model that is not muddled due to the inclusion of the ambiguity aversion construct. All the new analysis followed the exact same procedures used heretofore. To

reiterate, the only difference is the exclusion of ambiguity aversion, all other relationships remain the same. The results of the hierarchical regression are provided in Table 5-28.

Table 5-28

3SLS RESULTS FOR REVISED MODEL

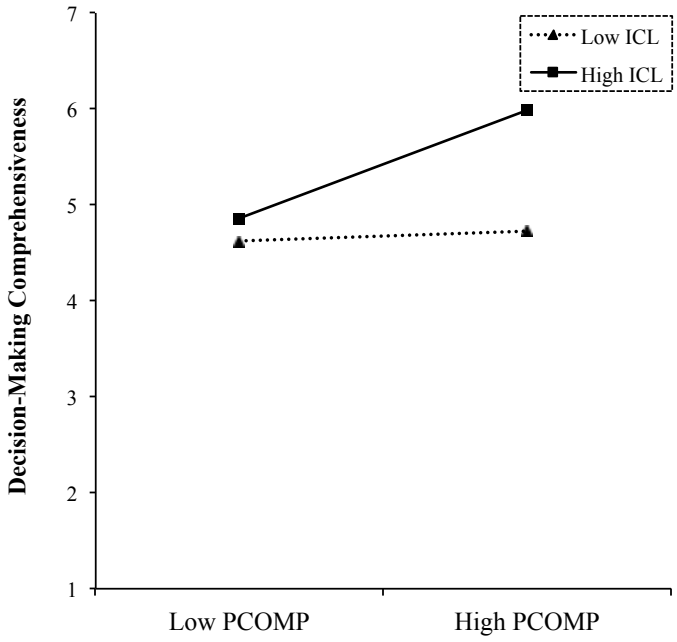
Equation	β	Standardized Coefficient	t-value	*p* value
Dependent Variable: FPS				
Intercept	0.365	0.0	1.12	0.265
DMC	0.333	0.297	5.00	<.0001
CAPI	0.557	0.638	10.67	<.0001
Dependent Variable: CAPI				
Intercept	1.240	0.0	5.05	<.0001
ICL	0.758	0.773	15.66	<.0001
Dependent Variable: DMC				
Intercept	5.136	0.0	83.96	<.0001
PCOMP	0.195	0.252	3.54	0.001
FNE	-0.104	-0.161	-2.48	0.014
ICL	0.295	0.386	5.49	<.0001
PCOMP x ICL (PXIc)	0.101	0.170	2.60	0.010
FNE x ICL (FXIc)	0.116	0.202	3.06	0.003

System Weighted MSE = 0.991
Degrees of Freedom = 496
System Weighted R-Square = 0.567

Using 3SLS estimation, the regression parameter estimates for the revised model are much improved. The R-square reported is 0.57, which is significantly higher compared to the (old) full model with covariates. The parameter estimates are all significant and in the expected direction. Interestingly, the relationship between PCOMP and DMC was moderated by innovation culture. The same was the case in regards to the relationship between FNE and DMC.

I further examined the interaction both using simple slope analysis. Figure 5-4 shows a graphical representation of how the relationship between perceived competence and decision-making comprehensiveness is moderated by innovation culture.

Figure 5-4 – Simple Slope Analysis of PXIc on DMC

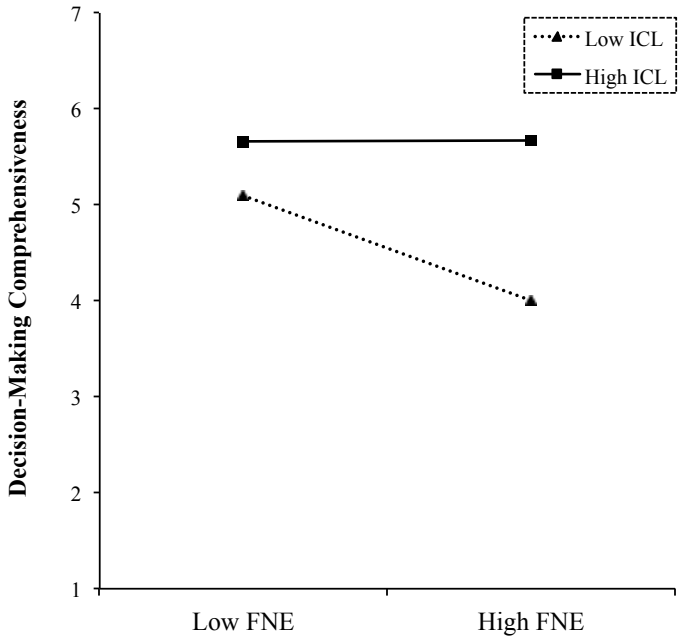


The slopes clearly show that while a low innovation culture has limited bearing on the relationship between PCOMP and DMC, when innovation culture is high, it serves to enhance the relationship between PCOMP and DMC in a positive manner. In other words, when managers with high perceived competence are in a firm culture high on innovation, this serves to increase their decision-making comprehensiveness.

Figure 5-5 below shows the slope analysis for the interaction of fear of negative evaluation and innovation culture on DMC. Once again, the slopes concur with the

significant interaction term from the hierarchical regression. The diagram suggests that a low innovation culture tends to accentuate the negative relationship between fear of negative evaluation and decision-making comprehensiveness.

Figure 5-5 – Simple Slope Analysis of FXIc on DMC

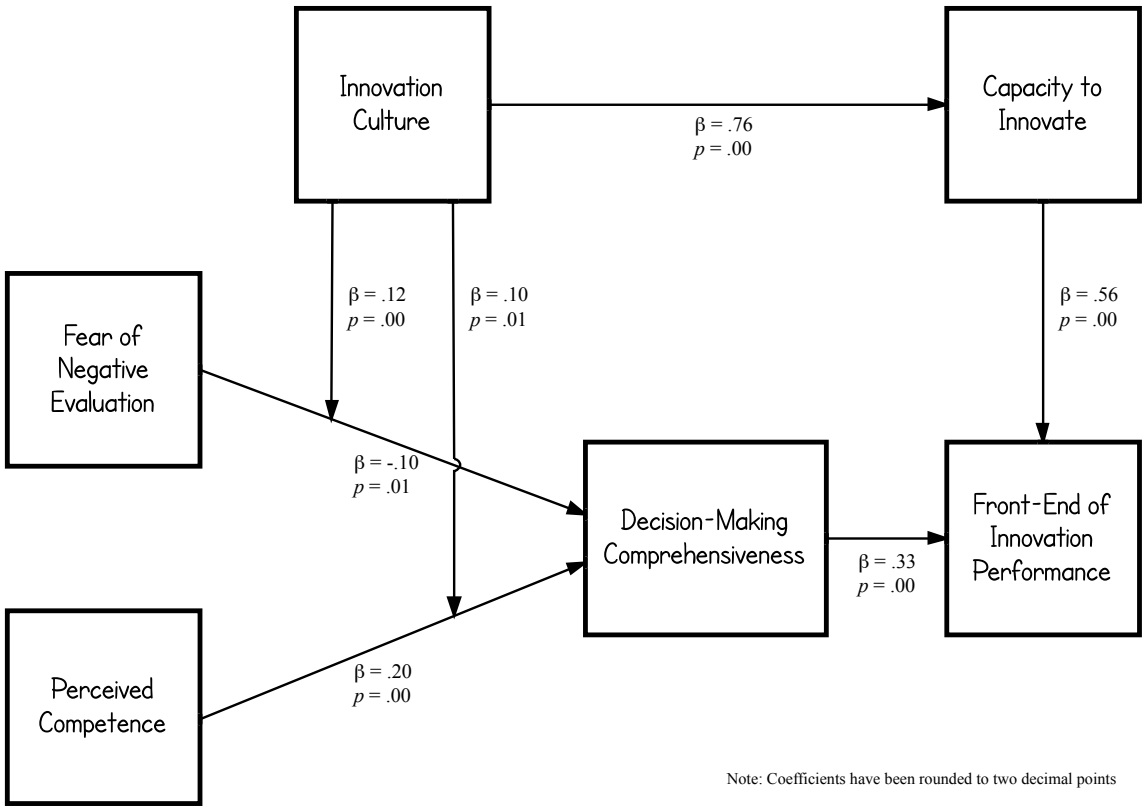


I further examined the moderations by subjecting them to Preacher and Hayes Model 1 test. The results again found that both moderations were in fact significant. Therefore, based three different types of analysis, I found strong support for the moderations pointed out in the revised model.

As previously discussed, I also examined the mediation relationships in the revised model. The results suggest that the effect of FNE on FPS is mediated by DMC, same with PCOMP on FPS, and the effect of ICL on FPS is mediated by CAPI. The

results of the mediation test are reported in Table 5-27 (p. 172). Figure 5-6 shows the suggested revised model. I provide a through discussion on this model in Chapter VI where I also examine why ambiguity aversion did not fit in well within the current framework.

Figure 5-6 – Revised Model with Path Coefficients



5.5.6. Tests of Regression Model Assumptions

As discussed, this dissertation employs hierarchical regression using 3SLS estimation to test proposed hypotheses. In general, this technique is fairly robust to violations of the basic assumption of regression. Nevertheless, all the four major assumptions of regression were examined as recommended by Hair et al. (2010). This

included testing for normality, linearity, independence, and heteroscedasticity. I tested these assumptions against a series of multiple regression equations that represent the main effects proposed in the model.

Normality can be judged by examining histograms with normal distributions, checking for degree of kurtosis and skewness, analyzing Q-Q plots, and looking at the Kolmogrov-Smirnov statistic. An examination of the relevant histograms indicated that the normality assumption is met because I obtained normal looking plots. Secondly, I made a probability plot and found the standardized residuals to fall along the line. This again suggests normality. Based on these assessments of the histograms and probability plots for each of the multiple regression that were run, it is clear that we can assume normality in the data.

Linearity is the assumption that the model possesses the properties of both additivity and homogeneity. Testing for linearity can be done using standardized or studentized residual plots. When using the plots, one needs to look for any consistent curvilinear pattern in the residuals. If such a pattern is found then corrective action, like transforming the values, is warranted. I examined standardized plots to get an accurate estimate of linearity, and based on the lack of pattern in the plots, the linearity assumption was met.

Uncorrelated error requires the predicted value to not be related to any other prediction. The Durbin-Watson D statistic was examined to check for uncorrelated errors (i.e. independence of the error terms). An ideal range for the Durbin-Watson D Statistic is between 1.15 and 2.25. After running the series of multiple regressions in SPSS, all

the Durbin-Watson D Statistics fall within the recommended range (they ranged between 1.77 and 2.11). One can also examine the standardized residual plots to look for patterns (an indicator of correlated errors). Based on the Durbin-Watson D Statistic and an examination of the residual plots, we can safely assume that we have met the independence assumption.

Unequal variances, or heteroscedasticity, is a common and serious problem in regression analysis. Regression assumes that we do not have heteroscedasticity. To test for heteroscedasticity, residual plots or simple statistical tests can be used. Residual plots with a consistent pattern are considered heteroscedastic. An examination of the standardized residual plots showed no discernable patterns, therefore we can assume that we have not violated this assumption of regression by having heteroscedastic data.

Additionally, multicollinearity was also examined. One can easily detect collinearity issues if there are variance inflation factors that exceed the recommended threshold of 10. All variance inflation factors obtained from the series of multiple regressions were below 2, suggesting that there is no concern in regards to multicollinearity. Overall the diagnosis of the data suggests that there is little concern regarding any violations of the basic assumption of regression.

5.6. Chapter Summary

This chapter provided a detailed review of the various data analysis steps taken to posit the data to the conceptual model. Initially all sample characteristics were examined, including firm and respondent characteristics. This was succeeded by a thorough effort to build an acceptable measurement model. This included running a number of EFAs and

CFAs to ensure that we have adequate measurement quality. Once this was achieved, I proceed to hypothesis testing. I utilized hierarchical regression using 3SLS estimation to arrive at parameter coefficients in order to determine if there was enough support for the proposed hypotheses. I also performed detailed assessments of moderation and mediation. Based on the results, I proposed a revised model as shown in Figure 5-6 (p. 177). The next chapter provides a detailed discussion of the results and their implications for theory and practice.

CHAPTER VI

DISCUSSION AND CONCLUSION

6.1. Introduction

This chapter is organized into five sections. The first and second sections provide an overview of the dissertation and a discussion of the research findings respectively. This includes a detailed overview of the proposed revised model, and why ambiguity aversion did not work within the current framework.

The third section provides an overview of the relevant implications of the current study. In addition to pointing out various theoretical contributions, I also go over various suggestions for managers. The next section discusses the limitations encountered in the dissertation. This is mostly centered around research limitations and its impact on the takeaways of the study.

The final section outlines various directions for future research. In conducting the current study, it is clear that there are multiple avenues of further inquiry that are of both theoretical and practical significance.

6.2. Overview of the Dissertation

The main goal of this dissertation was to examine the role of managerial aversion to ambiguity in innovation related decision-making. In doing so, there was a concerted effort to investigate the impact of ambiguity aversion on front-end of innovation performance. To be more specific, the dissertation outlined three specific research questions in Chapter I:

4. What leads to a situation where a decision-maker exhibits ambiguity aversion?
5. Does a decision-maker's ambiguity aversion impact front-end innovation performance? If so,
6. Under what circumstances can the impact of ambiguity aversion on the front-end of innovation be managed?

In order to address these pertinent questions, a conceptual framework, based on extant academic literature, was developed (see Figure 1-1, p. 7). Fear of negative evaluation and perceived competence are antecedents to ambiguity aversion. These two relationships are moderated by the firm's innovation culture; a never before studied conceptualization. I suggested that ambiguity aversion has a negative impact on decision-making comprehensiveness. Here, decision-making comprehensiveness is defined as "the degree to which the team is exhaustive as it considers multiple approaches, courses of action, and decision criteria in its strategic decision making" (Slotegraaf and Atuahene-Gima 2011, p. 97). Subsequently, decision-making comprehensiveness is positively related to front-end of innovation performance. The basic contention in the framework suggests that ambiguity aversion impacts front-end of

innovation performance because of the suppression effect it has on decision-making comprehensiveness. An ancillary relationship, one that has been previously studied, innovation culture to capacity to innovate leading to front-end of innovation performance is suggested.

A research design was crafted in order to test the conceptual model against actual data. Data was collected via the use of an online panel that consisted of managers involved in innovation related decision-making. After cleaning the data, there were a total of one hundred and seventy two usable responses. Appropriate steps were taken to assess the measurement quality of all constructs and based on accepted criteria summated variables for hypothesis testing were created. Support for hypotheses was based on the results of a series of regression equations that were a representation of the paths suggested in the conceptual model. All regression equations were estimated using three stage least squares estimation technique which allows for simultaneous estimation of regression equations. To gain further insights, various control variables were added to the regression equation as covariates. Further tests of mediation and moderation were also performed in order to correctly find support for some of the proposed hypotheses.

Based on the analysis of the data, certain additions by way of covariates were proposed to the original conceptual model. In addition, a revised conceptual model is also offered given the overall pattern of results obtained. As will be discussed in the next section, the revised model excludes ambiguity aversion from the conceptual model. This revised model is a noticeably better fit for the data. Taken either way, the results and overall insights gained suggest important implications for both theory and practice.

6.3. Discussion of Research Findings

As hinted in the previous chapter, there are two models that warrant a thorough discussion of their respective results. The first model more closely resembles the original conceptual model proposed in this dissertation. In addition to all of the originally proposed relationships, it adds one more in the form of a covariate on ambiguity aversion. This specific covariate represents the manager's years of experience in innovation related activities. A number of other control variables were examined, but none of them seemed to provide adequate justification that would merit their inclusion in the model. Figure 5-1 (p. 165) gives a thorough overview of this newer model along with the relevant path coefficients.

The overall system weighted R-square for this model is 47.4%, suggesting that explanatory power of the model with the added covariate is very good. As explained in Chapter V, adding the covariate serves to strengthen some of the hypothesized relationships. The overall pattern of results that emerged was inline with the conceptualized model barring one of the proposed moderations.

Both capacity to innovate and decision-making comprehensiveness were shown to have a strong and positive relationship with the dependent variable, front-end of innovation of performance. Extant literature has suggested that capacity to innovate is a key antecedent to firm competitive advantage and performance (Hurley and Hult 1998). It stands to reason that a similar relationship would exist between capacity to innovate and front-end of innovation, a relationship that has not been explored in the past. Therefore the results provide strong support for H8. Similarly, prior research has

established that decision-making comprehensiveness positively impacts new product advantage (Slotegraaf and Atuahene-Gima 2011). The conceptual model in this dissertation suggests that this team-level construct should have a similar positive impact on front-end of innovation performance. The results provide support for this conceptualization (H6).

As explored by Hurley and Hult (1998), the results replicate their finding of innovation culture having a positive relationship with capacity to innovate. In other words, the dissertation finds strong support for H7. To remind the reader, capacity to innovate was primarily included in the model, as without it, it is conceptually problematic to suggest that a culture would have a direct impact on a performance variable. Therefore, inherent in this argument is that capacity to innovate mediates the relationship between innovation culture and front-end of innovation performance. This relationship was testing using both the tried and tested procedures outlined by Baron and Kenny (1986) and the newer bootstrapping methods proposed by Preacher and Hayes (2004). The results of both procedures clearly provide support for complete mediation. This provides strong support for the inclusion of capacity to innovate in the model.

The remaining relationships in the conceptual model include the ambiguity aversion construct in one way or another. Hypothesis 5 suggested that ambiguity aversion has a significant negative relationship with decision-making comprehensiveness, suggesting that teams would exhibit lower decision-making comprehensiveness if the perceived their project leader to have a high level of ambiguity aversion. The cognitive miser theory was used to further explain this relationship. The results of hypothesis testing do in fact offer support for this hypothesis. The coefficient is negative and the *p*

value is below the .05 threshold. This relationship is another key part of the conceptual model. Taken along with H6, the result provides support to that the idea that ambiguity aversion is harmful in terms of performance.

Hypotheses 1 and 2 were concerned with antecedents of ambiguity aversion, fear of negative evaluation and perceived competence respectively. In other words they both suggest direct main effects, H1 being negative, while H2 proposing a positive relationship. However, the conceptual model also posits two moderation hypotheses. Innovation culture is hypothesized to moderate the relationship between fear of negative evaluation and ambiguity aversion (H3), and the relationship between perceived competence and ambiguity aversion (H4). The presence of the moderation hypotheses serves to supersede the direct effect hypotheses.

The results of hypothesis testing here provide some interesting findings. The moderation of innovation culture on the fear of negative evaluation – ambiguity aversion relationship is not supported (H3). The conceptual model had originally argued that under a weak innovation culture, a project leader with low FNE would exhibit a higher level of ambiguity aversion. This conceptualization was justified based on the premise that in a low/weak innovation culture there is no incentive to embrace ambiguity. In other words, regardless of whether a project leader experiences high or low FNE, he/she would always show high aversion to ambiguity in a low/weak innovation culture. The strong positive relationship between fear of negative evaluation and ambiguity aversion was expected in the strong innovation culture. Given the moderation, the main effect however remains strong and significant (H1). This implies that the effect of fear of negative evaluation on ambiguity aversion cannot be attenuated in the presence of either

a strong or weak innovation culture. The simple analysis confirms this result (see Figure 5-2, p. 166).

The results are less straightforward when examining H2 and H4, hypotheses dealing with perceived competence, ambiguity aversion, and innovation culture as a moderator. The hypothesis test for (H4) the moderation of innovation culture on the relationship between perceived competence and ambiguity aversion obtained significant coefficients. In other words, the results of the regression suggested that the innovation culture and perceived competence did have a significant interaction effect on ambiguity aversion. However, upon analyzing this relationship using simple slope analysis (see Figure 5-3, p. 167), the relationship is contradictory to that specified in H4.

Therefore while the interaction is significant, the data actually suggests that in a low innovation culture, there exists a negative relationship between perceived competence and ambiguity aversion, while in a high innovation culture that relationship is positive. This outcome is slightly problematic, and rather than providing answers, it only leads to further questions regarding the conceptual theorizing employed to come up with the hypothesis. It is especially difficult to rationalize why a manager would exhibit high ambiguity aversion when s/he is in a firm that is high on innovation culture while they experience high (low) perceived competence. This was conceptualized to be a circumstance when ambiguity aversion is at its lowest (highest).

Similarly, in a low innovation culture, ambiguity aversion is conceptualized to be high regardless of the level of perceived competence because there is no incentive in such

a culture to embrace ambiguity. Again, the finding of a negative relationship outlined in the simple slop diagram is highly counter-intuitive and difficult to explain.

In order to further understand these results, the moderation hypotheses were examined using Preacher and Hayes' method. Using the PROCESS macro in SAS 9.3, the variables were specified according to Preacher and Hayes' Model 7 which tests the interaction of ICL on the relationship between FNE (PCOMP) and AA while also accounting for the mediation relationship of FNE (PCOMP) to AA to DMC. The results indicated that neither moderation were significant. Furthermore, I performed mediation tests on the FNE (PCOMP) → AA → DMC relationships. The results here suggested that there was no presence of mediation. A further examination of the mediation test results suggested that there existed a strong direct effect of FNE (PCOMP) on DMC even when accounting for ambiguity aversion.

Given the overall pattern of results and the findings of the moderation and mediation tests, there is concern that ambiguity aversion is a poor fit in the current model. Accordingly, all the relevant analysis was rerun for a revised model that excluded ambiguity aversion. As pointed out in the previous chapter, procedures employed for hypotheses testing and other required tests followed the exact same procedures as previously employed. The revised model shows great promise (see Figure 5-6, p. 177). The system weighted R-square increased to 56.7%, suggesting that the explanatory power of the revised model is greatly enhanced.

Hypotheses 6, 7, and 8 are identical to the previous model and the results of hypotheses testing remained the same as before. Of more interest are the results relating

to the relationships between PCOMP, FNE, ICL, and DMC given the exclusion of ambiguity aversion in the revised model. The results of the relevant regression analyses provide support for the moderation effect of innovation culture on the relationship between FNE (PCOMP) and DMC. The results are further supported based on the outcome of the Preacher and Hayes tests for moderation. Since, the interaction terms are significant, further assessment of the moderations were examined via simple slopes analyses.

The simple slope analysis of the interaction of innovation culture on the relationship between fear of negative evaluation and decision-making comprehensiveness suggests a straightforward interpretation (See Figure 5-3, p. 174). Given a high innovation culture, the relationship between fear of negative evaluation and decision-making comprehensiveness is unclear (although DMC remains high throughout). This would suggest that a firm that exhibits a strong innovation culture is going to be high on decision-making comprehensiveness regardless of the manager's fear of negative evaluation as they don't have the option not to be comprehensive, or ignore being comprehensive. On the other hand, given a low innovation culture, there exists a negative relationship between fear of negative evaluation and decision-making comprehensiveness. The observed pattern of results might be explained by the freeze response to fear or even atychiphobia - the fear of failure. Since these concepts in psychology are closely related to motivations, it may be a theoretical lens that could be applied to explain the relationships discussed here.

Looking at Figure 5-4 (p. 175), the simple slopes representing the interaction of innovation culture and perceived competence on decision-making comprehensiveness

make reasonable sense. While a low or weak innovation culture has no bearing on the relationship between perceived competence and decision-making comprehensiveness, a high or strong innovation culture leads to a positive relationship. Therefore we can say that in an environment characterized by strong innovation culture, a manager is likely to observe higher decision-making comprehensiveness when s/he has high perceived competence over the decision scenario or context, as opposed to when s/he is on low perceived competence.

So in other words, if a manager feels highly competent, it is likely that they will push their project teams to consider all appropriate courses of action and strategies related to decisions involved with new product concepts or ideas obtained in the front-end of innovation. This behavior could be explained by an individual's need to see his/her decision being proven right. A manager who perceives high competence is unlikely to want their decisions (based on their high perceived competence) shown to be wrong. This conceptualization fits in well within the broad realm of rational choice theory and concepts of bounded rationality. A manager, being a rational actor, is going to be interested in making decisions that provide the greatest self-benefit or self-interest. Therefore, an individual with high perceived competence is going to want to ensure that his or her decisions are in fact right by ensuring that decision-making comprehensiveness is high. This would especially be the case in a high innovation culture due to the greater emphasis placed on both positive and negative outcomes associated with innovation related decisions.

Mediation tests were also performed. The results strongly support the mediation role of decision-making comprehensiveness on the path from FNE (PCOMP) to front-end

of innovation performance. This finding is key as it is theoretically improbable to suggest that perceived competence and fear of negative evaluation directly impact a performance variable.

6.3.1. Discussion on Ambiguity Aversion

A troubling outcome of the revised model is the non-inclusion of the ambiguity aversion construct. The inclusion of ambiguity aversion in the original conceptual model was based on an extensive review of the literature and a solid theoretical foundation. Needless to say, it is a key variable within the proposed conceptual model. Given this, it is imperative to further examine the subsequent lack of adequate findings in relation to the various hypothesized paths directly related to the ambiguity aversion construct.

The failure to find strong support for ambiguity aversion in the model could be attributed to a number of reasons. One key area is to examine are any violations of the basic assumptions of the regression model. As outlined in Chapter V, I have previously assessed these assumptions and found no major violations. However, in order to make absolutely certain, I retested these assumptions with a specific focus on the ambiguity aversion measure. While the results show that the assumptions of independence and homoscedasticity are more or less met, there appears to be issues with normality and to a greater extent, linearity. Normality was examined by looking at a histogram of the residuals with a normal distribution curve added. Examining the Q-Q plot performed an additional test of normality (see Appendix E). Both charts indicate that apart from minor deviations, the distributions are more or less normal. However, on examining statistical tests for normality (Kolmogorov-Smirnov test and the Shapiro-Wilk test), the null

hypothesis that the distribution is normal is rejected. As such, the tests for the assumption of normality are somewhat inconclusive, but due to the various limitations surrounding both statistical tests, we can assume that the AA variable is normally distributed.

Of more concern is the failure to meet the linearity assumption. The linearity assumption in regression assumes that there exists a linear relationship among variables. Regression is highly susceptible to bad, poor, and/or misleading results if the variables do not exhibit a linear relationship. The linearity assumption was examined by assessing scatter plots of ambiguity aversion against perceived competence, fear of negative evaluation, and decision-making comprehensiveness. The presence of a linear pattern in the scatter plot suggests that there exists a linear relationship. The scatter plots revealed no discernible pattern that would suggest linearity. Linearity can also be examined by way of looking at Pearson's correlations. High and significant correlations are a stepping-stone towards establishing linear relationships. However, again this was not the case, correlations were low and insignificant. Prescribed remedies to counter non linearity often advocate the transformation of the variables involved. A number of transformations were performed on ambiguity aversion (including log, inverse, square root, and square). However, as shown in Appendix E, none resulted in a scatter plot that would allow us to satisfy the linearity assumption. Therefore, one conclusion for the problems related to ambiguity aversion in the model could be its inability to meet all the basic assumptions of regression. (Appendix E outlines the various tests and charts used to ascertain whether the ambiguity aversion measure meets the four assumptions).

In performing various transformations and tests to ascertain linearity, I also examined whether or not ambiguity aversion had a curvilinear relationship with its related variables. Curvilinear relationships were examined by performing a curve estimation analysis in SPSS. The results were clear in that there was no evidence to suggest a curvilinear relationship with either of the antecedents (PCOMP and FNE) or with decision-making comprehensiveness. Therefore, the failure to detect a strong reason to include ambiguity aversion in the model cannot be explained due to the presence of curvilinear type relationships.

Another important issue that needs to be addressed is the measurement of the ambiguity aversion construct. As pointed out in the previous chapter, a number of issues arose when ambiguity aversion was examined via exploratory factor analysis, reliability analysis, and confirmatory factor analysis. The decision at that stage was to use just two items (AA2 and AA5) to represent the ambiguity aversion construct. This was based on the fact that the reverse coded AA3 item did not correlate well with any of the other items, and two items AA1 and AA4 seemed to represent a completely different factor from AA2 and AA5.

This outcome might suggest that the newly developed scale has been poorly developed given the definition adopted in the dissertation. As will be discussed later, this is a promising area of future research as there is no existing scale that does a good job of measuring managerial aversion to ambiguity. Finally, one could point at sample related issues or even theoretical problems in causing the lack of support for ambiguity aversion. However, these issues can be dismissed on a number of grounds. For example, additional variables measured (that are not reported in the dissertation) like risk aversion was used

to examine their relationship to ambiguity aversion. Theory suggests that ambiguity aversion and risk aversion are different. A t-test for mean separation between risk aversion and ambiguity aversion confirmed that they are indeed different. In addition, the variables exhibit low and non-significant bivariate correlations (Pearson's $r = 0.115$, $p = 0.132$). Similarly, risk aversion and ambiguity aversion exhibit good discriminant validity when compared with each other. While there is yet more to be done to examine these findings, it is safe to discard problems with theoretical development or sample related issues as being the cause for a lack of significant findings related to ambiguity aversion.

In summary, it is likely that a number of reasons have contributed to the pattern of results that are not in favor of ambiguity aversion. This includes the inability to meet the basic assumptions of regression and the concerns arising from the measurement of the construct.

6.4. Research Implications

The following section describes the key implications of the dissertation. There are a number of key takeaways from this research. I first focus on the theoretical implications of the current framework. This is followed by the practical or managerial implications of the findings. Taken together, it is clear that the dissertation has allowed us to make major strides in both theory and practice.

6.4.1. Theoretical Implications

There are a number of propositions that the dissertation provides in regards to theory. First, the current study extends our current understanding of the front-end of innovation. As pointed out earlier, the front-end of innovation is generally underexplored especially in terms of managerial attributes like decision-making. They key focus of extant research in this area has been to make process related recommendations. The study presented here is the first of its kind to examine how managers can directly influence front-end of innovation performance. The key here is how competent a manager perceives himself to be, and his/her fear of negative evaluations post-decision. The findings suggest that both impact front-end of innovation performance through their impact on decision-making comprehensiveness. This conceptualization capture both the individual and team level attributes that could impact performance at the front-end which is another key theoretical contribution.

In terms of past research, many have advocated the role of innovation culture on innovation related performance (via capacity to innovate). However, few have examined how innovation culture moderates individual managerial factors like perceived competence and fear of negative evaluation, factors that could have an impact on innovation related decision-making. The findings of the dissertation suggest that innovation culture does moderate the relationship between perceived competence and decision-making comprehensiveness. The same goes for the relationship between fear of negative evaluation and decision-making comprehensiveness. This finding is a key theoretical contribution. What we have is support for the long-standing conceptualization

that organizational or firm culture does indeed play a role in decision-making amongst managers.

An equally important contribution is the finding in support of the role of innovation culture within a framework dealing with the front-end of innovation. Extant research has not adequately examined how innovation culture may impact activities, decisions, and performance at the front-end of innovation. This dissertation shows one possible framework in which this may be the case. Finally, another contribution here is the measurement of innovation culture. We have replicated the findings of Dobni (2008) in regards to measuring innovation culture via a multi-item subjective scale. The measure's strong relationship to front-end of innovation performance via capacity to innovate (a newly developed scale) is exactly as theorized. This bodes well for further studies in the area.

Continuing on the discussion about scales and measures, this dissertation develops a number of new multiple item scales to measure constructs. Barring the ambiguity aversion measure, all other scales performed remarkable well. While the scale development efforts undertaken here are by no means exhaustive, the current results provide great promise in terms of the new measures and serves as another contribution to future research in these areas.

Finally, I contend that the results help to further expand our knowledge of the front-end of innovation, and the wider innovation domain. To the best of my knowledge, this is the first attempt to bring concepts from both normative decision theory and behavioral decision theory into the innovation context. This helps to expand the

generalizability of these theoretical domains. In addition, it also suggests that managerial decision making in the front-end of innovation, and other aspects related to innovation can be adequately studied through these theoretical perspectives in a manner that brings about key conclusions and findings. Overall, these theoretical contributions taken together help further our current state of knowledge while also opening up various avenues for further inquiry.

6.4.2. Managerial Implications

There are a number of key recommendations and implications for managers that arise from the findings in this dissertation. Managers (and firms) are constantly exploring various ways to improve their innovation performance or innovativeness in general. This could include efforts to bring in a culture with high regard for innovation, or adopting processes that increase the ability to be innovative. Either way, there is increasing demand on how to be better at innovation. This phenomenon can be explained due to the increasing evidence in support of the key role of innovation in overall firm performance and developing competitive advantages.

A key finding is that decision-making comprehensiveness is positively linked to front-end of innovation performance. Team work is part and parcel of innovation related activities. These teams are responsible for multiple activities and provide input on innovation related decisions. The role of project teams has been discussed prominently within the new-product development literature. However, there has been less effort devoted to understanding the role of teams in the front-end of innovation. We already know that the front-end of innovation is often characterized as being associated with

activities and decisions that are difficult to explain, describe, explain etc. In other words, the inherent nature of early concepts and ideas being vague and uncertain makes it difficult to predict success at this early stage. The findings in this dissertation strongly contend that team decision-making comprehensiveness helps improve the performance at the front-end of innovation.

How comprehensive project teams are in assessing various alternative strategies, options, decision criteria etc. have direct effect of front-end of innovation performance. Being high on decision-making comprehensiveness serves to reduce the inherent fuzziness or vagueness associated with the activities and outcomes at the front-end of innovation. This is because project teams are more exhaustive in considering multiple strategies, differing courses of action, decision criteria etc. This would include being thorough in establishing probabilities for attributes, outcomes, or specifics that are ambiguous. This allows concepts and ideas emerging from the front-end to have been subject to a more extensive screening process, be better defined, and be associated with well-established probabilities. This essentially serves to improve the overall quality of the outcome of the front-end of innovation, thus leading to a domino effect on performance at latter stages of innovation.

Another finding that serves to improve front-end of innovation performance is through that of the role played by a firm's capacity to innovate. As pointed out by Hurley and Hult (1998), innovative capacity refers to a firm's ability to adopt new ideas, processes, and/or innovations in a successful manner. It is in some ways the tangible manifestation of a strong innovation culture. Capacity to innovate has been shown to be a strong predictor of innovation performance. This dissertation further teases out the key

role of this construct on improving performance at the front-end of innovation, a relationship that hasn't been explored previously. This dissertation finds that innovation culture has a significant impact on front-end of innovation performance through its role on capacity to innovate. This would suggest that in order for firms to find success during the early stages of innovation, it is key that they have the underlying capacity to innovate. In other words, a firm needs to have a strong and successful ability to adopt and advance new ideas in order to find success at the front-end of innovation.

Another key implication directly pertains to various recommendations that could help enhance front-end of innovation performance through various managerially relevant traits. The revised model suggests that high perceived competence has a positive effect on decision-making comprehensiveness which in turn results in increased front-end of innovation performance. In other words, a manager that perceives high competence over the decision context might be beneficial in terms of innovation performance. Perceived competence here refers to skills, expertise, knowledge etc. over the decision context. Therefore, managers should be afforded every opportunity to expand on their competencies. This could be in the form of additional training or further education, access to key information etc. It could also be that perceived competence is linked to overall experience.

Similarly, the revised model suggests that fear of negative evaluation can be detrimental to front-end of innovation performance. However, as discussed below, this relationship is moderated by the firm's innovation culture.

Most important is the role innovation culture plays in moderating the relationship between perceived competence and decision-making comprehensiveness and fear of negative evaluation on decision-making comprehensiveness. Innovation culture attenuates the effect of fear of negative evaluation, while enhancing the effect of perceived competence on decision-making comprehensiveness. In other words, having a culture that places a strong emphasis on innovation is key to improving decision-making comprehensiveness. This is a key finding because as I have explained earlier, there is little we currently know in regards to how firms can do better in terms of front-end of innovation performance.

In summary, the results of the revised model serves to provide a valuable framework through which firms and managers can improve front-end of innovation performance.

6.5. Research Limitations

Here I discuss a number of research limitations that warrant a more in depth discussion. One limitation of the current study is the overall generalizability of the results. This limitation arises from the disproportionate number of large firms in the current sample. As discussed in the previous chapter, the greater proportion of large firms in the sample is significantly different from the distribution of firm size seen in the population of companies in the United States. The lack of a large number of small to medium sized firms in the sample maybe due to the sampling procedures employed and/or due to the screening question that was incorporated. Nevertheless, it doesn't

necessarily discount the significance of the results here; it merely necessitates one to exercise caution in generalizing the results to smaller sized firms.

The major concern in research such as the one presented here is the use of single-respondent data, or in other words, the lack of multiple responses from each firm. This limitation was unavoidable due to time and financial constraints beyond the control of the research team. The negatives associated with single respondent data can be remedied based on the recommendations of Campbell (1955) who notes that it is acceptable if the single respondent is highly knowledgeable in the domain of study. The use of various sampling and screening methods employed in this dissertation serves to ensure that respondents do indeed fit the description of key informants. For example, the screening question employed at the start of the survey ensures that all respondents are deeply involved in innovation related activities and decision-making.

However, there is still the issue of using one respondent's evaluation for constructs like decision-making comprehensiveness and performance. Ideally, members of a project team rather than a project leader should evaluate decision-making comprehensiveness. Similarly, performance should ideally be captured using objective measures rather than relying on manager's subjective evaluations. Therefore, while every effort was made to reduce the reliance on single source data, it is a limitation that we have to accept here.

Non-response bias is often a concern in survey type research. It is often assessed by way of comparing early and late responses to the survey. No differences between the two would indicate that there is no non-response bias. However, the design of the current

study deviates in a number of ways from traditional survey based studies. First, it employs the use of a research panel provider to provide participants for the study, and second, the survey is administered online. These two points taken together constitute a non-traditional approach to survey design. For example, this use of this research design is partly responsible for having collected all the required responses over the span of a few days. Thus, examining difference between early and late responses is futile. As a result of the quick turn around on data collection, we assume that non-response bias is not an issue here.

Another limitation is the lack of control associated with correlational studies. Unlike experiments, survey based research has limitations in terms of its ability to control extraneous variables. This introduces threats to internal validity. Attempts to mitigate these issues included measuring additional variables that are known covariates to the key variables of interest. And finally, there are serious measurement issues related to the ambiguity aversion measure which were discussed earlier.

6.6. Directions for Future Research

Ultimately, this dissertation is just one step in what is a never-ending process of research. As we understand the current domain of study better, more questions inevitably arise. The same is true here. There are a number of different directions that could serve as fruitful areas of further inquiry. Probably the most interesting area for further research is ambiguity aversion. There remains a startling lack of research on ambiguity aversion in the marketing domain. As discussed in Chapter II, the focus has mostly been on risk aversion. Both behavioral decision theory and normative decision theory provide great

insight into ambiguity aversion. Based on these two theoretical foundations, it is clear that ambiguity aversion should play a role in conceptual models similar to the one presented here. The original conceptual model presented in this dissertation includes ambiguity aversion as a key variable. However, as pointed out previously, there were a number of measurement issues that resulted in the exclusion of ambiguity aversion from the revised model. Nevertheless, this should not preclude future researchers in this area from excluding ambiguity aversion in their models. It is a phenomenon that is clearly different from risk aversion, and merits further inquiry in the field of marketing.

Another interesting direction for future research is to examine differences in how managers and team members perceive decision-making comprehensiveness. Obviously, it is a key component that describes performance at the front end of innovation. The current dissertation examines decision-making comprehensiveness from the manager's viewpoint. It would be interesting to see if the results will vary if the measurement was done at the team level. Also related to decision-making comprehensiveness, there is a need to further explain exactly how fear of negative evaluation and perceived competence play a role in decision-making comprehensiveness. In other words we need a theoretical justification for these relationships that are found in the revised model. This would be an area worthy of further inquiry.

Though it wasn't a central focus in this dissertation, researchers are strongly advised to look into the exact mechanisms through which managers perceive ambiguity aversion and risk aversion. There is room to suggest that ambiguity aversion supersedes risk aversion. This is based on the fact that ambiguity aversion deals with the lack of probabilities, while risk version is concerned with differences in given probabilities. An

interesting area of further inquiry would be to examine when a manager crosses over from being averse to ambiguity onto a situation where he or she is exhibiting risk aversion. In other words, would the appearance of probabilities automatically eliminate ambiguity aversion and lead to a situation more in line with risk aversion.

Future research in this area is encouraged to examine other antecedents of the front-end of innovation performance. This dissertation only examines capacity to innovate and decision-making comprehensiveness. It is likely that many more variables could play an important role in determining front-end of innovation performance. For example, how does reacting to competition impact activities at the front of an innovation? Many firms these days are forced to innovate purely because they need to stay abreast with their competition. It is possible, that speed and strength of competitive reactions could play a role in terms of how managers deal with decision-making at the front-end of innovation.

Another area of future inquiry remains in explaining the impact of innovation culture on various activities and decisions made in relation to innovation. While this dissertation has examined one mechanism through which innovation culture helps improve innovativeness and or innovation performance, there remain multiple other explanations that need to be examined. Innovation culture is admittedly a complex construct. Gaining a better understanding of it is key if we are to advance our understanding in the innovation domain. There is also a further need to examine how innovation culture can be effectively implemented within an organization. This is surely not easy, but the theoretical and managerial implications of such a study would be immense.

In closing, this dissertation set out to examine an interesting area of research, one with both theoretical and managerial implications. The results provide support for the general notion that there are multiple ways through which firms can improve performance of the front-end of innovation. While there are certain limitations to the study, the theoretical and managerial implications are noteworthy. Scholars conducting work in this area are strongly urged to continue their pursuit towards better explaining the issues discussed in this dissertation.

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APPENDICES

APPENDIX A

IRB PROTOCOL APPROVAL

Oklahoma State University Institutional Review Board

Date:	Monday, November 12, 2012
IRB Application No	BU1224
Proposal Title:	Ambiguity Aversion in the Front-End of Innovation
Reviewed and Processed as:	Exempt

Status Recommended by Reviewer(s): Approved Protocol Expires: 11/11/2013

Principal Investigator(s):

Mayoor Mohan
405C Business
Stillwater, OK 74078

Kevin E. Voss
211 Business
Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

[X] The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval. Protocol modifications requiring approval may include changes to the title, PI, advisor, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Dawnett Watkins 219 Cordell North (phone: 405-744-5700, dawnett.watkins@okstate.edu).

Sincerely,

Shelia H. Kennison

Shelia Kennison, Chair
Institutional Review Board

Oklahoma State University Institutional Review Board

Date	Wednesday, November 28, 2012	Protocol Expires:	11/11/2013
IRB Application	BU1224		
Proposal Title:	Ambiguity Aversion in the Front-End of Innovation		

Reviewed and Processed as: Exempt
Modification

Status Recommended by Reviewer(s) **Approved**

Principal Investigator(s) :

Mayoor Mohan
405C Business
Stillwater, OK 74078

Kevin E. Voss
211 Business
Stillwater, OK 74078

The requested modification to this IRB protocol has been approved. Please note that the original expiration date of the protocol has not changed. The IRB office MUST be notified in writing when a project is complete. All approved projects are subject to monitoring by the IRB

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

Signature :
Shelia Kennison, Chair, OSU Institutional Review Board

Wednesday, November 28, 2012
Date

IRB STATEMENT

PARTICIPANT INFORMATION
OKLAHOMA STATE UNIVERSITY

Title: Ambiguity Aversion in the Front-End of Innovation

Investigator(s): Mayoor Mohan, M.S., Oklahoma State University
Kevin Voss, Ph.D., Oklahoma State University

Purpose: This project examines the role of managerial decision-making in the front-end of a firm's innovation activities. In particular, we are examining the degree to which a manager's aversion to ambiguity impacts performance at the front-end of innovation.

What to Expect: "This research study is administered online. Participation in this research will involve completion of one questionnaire concerning innovation and decisions made in the area. It will take you approximately 20 minutes to complete the survey. You must complete each question before moving on to the next.

Risks: There are no risks associated with this project which are expected to be greater than those ordinarily encountered in daily life.

Benefits and Compensation: There are no direct benefits to you from completing the survey other than whatever compensation (if any) you receive from ResearchNow. The overall benefit of the project to society, however, will lie in insights gained in the nature of how firms innovate.

Your Rights and Confidentiality: Participation in this study is voluntary. There are no right or wrong answers, if you do not want to answer a particular question, just skip it. There is no penalty for refusal to participate, and you are free to withdraw your consent and participation in this project at any time, without penalty. All of the information you provide is confidential. Only summary information, which contains no identifying information, will be used for reporting purposes. To protect your privacy the responses you make are kept completely anonymous.

Contacts: You may contact any of the researchers at the following addresses and phone numbers, should you desire to discuss your participation in the study and/or request information about the results of the study: Mayoor Mohan, M.S., Spears School of Business, Oklahoma State University, 405-744-5192; Kevin Voss, Ph.D., Spears School of Business, Oklahoma State University, 405-744-5106. If you have questions about your rights as a research participant, you may contact Dr. Shelia Kennison, IRB Chair, 219 Cordell North, Stillwater, OK 74078, 405-744-3377 or irb@okstate.edu.

If you choose to participate: Please, click **NEXT** if you choose to participate. By clicking **NEXT**, you are indicating that you freely and voluntarily and agree to participate in this study and you also acknowledge that you are at least 18 years of age.
It is recommended that you print a copy of this consent page for your records before you begin the study by clicking below.

SURVEY ON FRONT-END OF INNOVATION

This research is being conducted by researchers at a major state university in the United States. The research is designed strictly to improve our understanding and ability to explain new product development processes at private companies. Your participation is part of large study that will have important impact on the business community. Your responses will help us better understand performance in innovation activities. *A specific goal is to help improve the outcomes and processes of the front-end of innovation.*

This survey concerns your experiences at your current or most recent job. Please think of the company that you currently work for (or most recently worked at) and keep this specific company in mind as you answer the questions in this survey. When you respond please respond only considering your actual experience at this current or most recent employer.

Of particular interest is your experience in specific *innovation* related experiences.

Thanks again for your participation in this important survey.

Okla. State Univ.
IRB
Approved 11/2/12
Expires 11/1/13
IRB # BU-12-324

APPENDIX B

SURVEY INSTRUMENT
Administered online via Qualtrics®

SCREENING QUESTION

The question below will help us ascertain whether or not you are a good fit for the current survey. Depending on your answer you will either be asked to complete the survey or presented with a statement thanking you for your participation.

How would you best describe your level of involvement in your company's decisions regarding *innovation/ new product ideas*?

- o I am the sole decision maker regarding ***innovation/ new product ideas*** **[QUALIFY]**
- o I make the final decision regarding ***innovation/ new product ideas*** with input from staff/management **[QUALIFY]**
- o I help reach the final decision regarding ***innovation/ new product ideas*** as part of a group/committee **[QUALIFY]**
- o I provide input toward decisions regarding ***innovation/ new product ideas*** **[TERMINATE]**
- o I have no input into decisions regarding ***innovation/ new product ideas*** **[TERMINATE]**

SURVEY ON FRONT-END OF INNOVATION

This research is being conducted by researchers at a major state university in the United States. The research is designed strictly to improve our understanding and ability to explain new product development processes at private companies. Your participation is part of large study that will have important impact on the business community. Your responses will help us better understand performance in innovation activities. *A specific goal is to help improve the outcomes and processes of the front-end of innovation.*

This survey concerns your experiences at your current or most recent job. Please think of the company that you currently work for (or most recently worked at) and keep this specific company in mind as you answer the questions in this survey. When you respond please respond only considering your actual experience at this current or most recent employer.

Of particular interest is your experience in specific *innovation* related experiences.

Thanks again for your participation in this important survey.

MANAGERIAL INFORMATION

I have adequate knowledge to assess this firm's:	Strongly Disagree						Strongly Agree
Experience with respect to managing innovation activities.	1	2	3	4	5	6	7
Skills with respect to managing innovation activities.	1	2	3	4	5	6	7
Capabilities with respect to managing innovation activities.	1	2	3	4	5	6	7
Motivations with respect to managing innovation activities.	1	2	3	4	5	6	7
Motivations with respect to profit goals for one or more products.	1	2	3	4	5	6	7
Motivations with respect to reacting to the competition.	1	2	3	4	5	6	7
Goals with respect to the future direction for product innovation activities.	1	2	3	4	5	6	7
Motivations with respect to cost control goals for product innovation activities.	1	2	3	4	5	6	7
Products' quality.	1	2	3	4	5	6	7

On the following questions please select your level of expertise, knowledge, or experience.	Strongly Disagree						Strongly Agree
I have many years of experience in innovation.	1	2	3	4	5	6	7
I very knowledgeable about new product development	1	2	3	4	5	6	7
I consider innovation an area in which I know what I am doing.	1	2	3	4	5	6	7
I have developed expertise in managing innovation.	1	2	3	4	5	6	7
I have developed expertise in managing product development.	1	2	3	4	5	6	7

MANAGERIAL EVALUATION

When I make decisions on new products ideas:	Strongly Disagree						Strongly Agree
I am afraid that others will criticize decisions I have made	1	2	3	4	5	6	7
I worry a lot about what my supervisors would think of my decision.	1	2	3	4	5	6	7
I worry a lot about what my co-workers would think of my decision.	1	2	3	4	5	6	7
These decisions are open to criticism by others.	1	2	3	4	5	6	7
I worry that the innovation related decisions I make might lead to ridicule within the company.	1	2	3	4	5	6	7
In our innovation process, out-of-the-box decisions may be negatively received	1	2	3	4	5	6	7
To gain positive feedback, innovation decisions must be based on accepted criteria.	1	2	3	4	5	6	7
To avoid negative feedback by other in the firm, I usually approve the most defensible innovation ideas.	1	2	3	4	5	6	7

MANAGING UNCERTAINTY

In relation to innovation activities:	Strongly Disagree						Strongly Agree
I believe that higher risks are worth taking for higher rewards.	1	2	3	4	5	6	7
I accept occasional failures as being normal.	1	2	3	4	5	6	7
To earn greater rewards, I am willing to take higher risks.	1	2	3	4	5	6	7
I like to "play it safe."	1	2	3	4	5	6	7
I like to implement a plan only if it is very certain that the plan will work.	1	2	3	4	5	6	7
I encourage the development of marketing strategies, knowing well that some will fail.	1	2	3	4	5	6	7

In relation to innovation activities:	Strongly Disagree						Strongly Agree
When it comes to uncertain outcomes, I need to know the odds for and against.	1	2	3	4	5	6	7
Problems that must be considered from multiple viewpoints are a little threatening.	1	2	3	4	5	6	7
I enjoy tackling problems that are ambiguous.	1	2	3	4	5	6	7
Before I can make a decision, understanding the probable outcomes must come first.	1	2	3	4	5	6	7
I would rather avoid solving a problem that must be viewed from several different perspectives.	1	2	3	4	5	6	7

UNCERTAINTY PREFERENCE

Within the context of your firm's innovation activities, how comfortable are you with:	Very Uncomfortable						Very Comfortable
Uncertain Situations	1	2	3	4	5	6	7
Uncertain Decisions	1	2	3	4	5	6	7
Uncertain Outcomes	1	2	3	4	5	6	7

Within the context of your firm's innovation activities, how comfortable are you with:	Very Uncomfortable						Very Comfortable
Situations That Involve Risk	1	2	3	4	5	6	7
Decisions That Involve Risk	1	2	3	4	5	6	7
Outcomes That Involve Risk	1	2	3	4	5	6	7

	Sure Bets						Long Shots
Which do you prefer when it comes to innovation related decisions:	1	2	3	4	5	6	7

Please read the following two statements carefully and then select the one that you feel best represents your approach in regards to your firm's innovation activities.

- I am comfortable making a choice between various options where the probability or odds associated with each option is clearly specified.

- I am comfortable making a choice between various options regardless of whether or not the probability or odds associated with each option is clearly specified.

Please read the following two decision scenarios carefully and then select the one that you feel most comfortable with.

- We have chosen to go with Concept # 1 and advance it to formal new-product development immediately. Our decision was based on extensive research which shows that Concept # 1 has a 76% chance of success compared to just 45% for Concept # 2.

- We have chosen to go with Concept # 1 and advance it to formal new-product development immediately. Our decision was based on extensive research which shows that Concept # 1 has a higher likelihood of success compared to Concept # 2.

RISK AVERSION VS. AMBIGUITY AVERSION

The front-end of innovation is often described as comprising a lot of uncertainty.

Conceptually, uncertainty can be divided into two dimensions; measurable and unmeasurable uncertainty.

In business, ***measurable uncertainty*** is often characterized as situations where we have access to clear and specific probabilities or odds. These probabilities or odds may be associated with decision choices, outcomes, etc. In other words measurable uncertainty is observable and quantifiable.

Measurable uncertainty is also referred to as risk.

Note that risk only refers to the presence of probabilities or odds not what those probabilities or odds may be.

	Very Uncomfortable						Very Comfortable
How do you feel about risk in innovation	1	2	3	4	5	6	7

In business, ***unmeasurable uncertainty*** is often characterized as situations where we do not have access to clear and specific probabilities or odds. These vague probabilities or odds may be associated with decision choices, outcomes, etc. In other words unmeasurable uncertainty is unobservable and not quantifiable.

Unmeasurable uncertainty is also referred to as ambiguity.

Note that ambiguity only refers to the lack of clear probabilities or odds, not the confidence we have in available probabilities or odds.

	Very Uncomfortable						Very Comfortable
How do you feel about ambiguity in innovation	1	2	3	4	5	6	7

INNOVATION CULTURE

In my company:	Strongly Disagree						Strongly Agree
Innovation is an underlying culture and not just a word.	1	2	3	4	5	6	7
Our senior managers are able to effectively cascade the innovation message throughout the organization.	1	2	3	4	5	6	7
Innovation is a core value.	1	2	3	4	5	6	7
We have an innovation vision that is aligned with current projects, platforms, or initiatives.	1	2	3	4	5	6	7

In my company:	Strongly Disagree						Strongly Agree
We find it easy to adopt new processes.	1	2	3	4	5	6	7
We definitely work at creating new ways to work.	1	2	3	4	5	6	7
Our skills translate into new innovations that benefit customers.	1	2	3	4	5	6	7
Innovation requires dynamic capabilities that we possess.	1	2	3	4	5	6	7

DECISION-MAKING COMPREHENSIVENESS

When I've been the decision maker of a new-product development team, we:	Strongly Disagree						Strongly Agree
Develop many alternative courses of action.	1	2	3	4	5	6	7
Use multiple criteria for eliminating possible courses of action.	1	2	3	4	5	6	7
Engage in extensive and in-depth analysis of all available strategic options	1	2	3	4	5	6	7
Thoroughly examine multiple explanations for problems and opportunities.	1	2	3	4	5	6	7

How many members usually make up a new-product development team at your firm:

_____

INNOVATION PERFORMANCE

Please select the appropriate response in the context of your innovation activities especially its early stages (also referred to as the front-end of innovation).	Strongly Disagree						Strongly Agree
The front-end results of new product projects I've led have been really good.	1	2	3	4	5	6	7
Front-end idea screening is considered a strength at my firm.	1	2	3	4	5	6	7
Front-end concept development processes are considered a strength at my firm.	1	2	3	4	5	6	7
When I think about our new-product development (NPD) processes, the front-end activities are excellent.	1	2	3	4	5	6	7
In our front-end process, we excel at producing solid product concepts for future development.	1	2	3	4	5	6	7
Product strategies that result from our front-end process are clear.	1	2	3	4	5	6	7
Our front-end idea screening produces sharp product definitions.	1	2	3	4	5	6	7
Product concepts that we recommend for further development are financially feasible.	1	2	3	4	5	6	7
A high percentage of our recommended concepts get funded for product development.	1	2	3	4	5	6	7
In our front-end process, we excel at producing clear product definitions.	1	2	3	4	5	6	7

How many new ideas were generated in your front-end of innovation process during the last:

3 Months _____
6 Months _____
12 Months _____
18 Months _____

How many new ideas emerged from your front-end of innovation process ready for development during the last:

3 Months _____
6 Months _____
12 Months _____
18 Months _____

What percentage of product concepts produced by your front-end of innovation process received funding during the last:

3 Months _____
6 Months _____
12 Months _____
18 Months _____

What percentage of your product concepts were abandoned or discarded during the last:

3 Months _____
6 Months _____
12 Months _____
18 Months _____

What percentage of product concepts produced by your front-end of innovation process were sent back for further analysis during the last:

3 Months _____
6 Months _____
12 Months _____
18 Months _____

ENVIRONMENTAL CHARACTERISTICS

In our business:	Strongly Disagree						Strongly Agree
Customers' product preference change quite a bit over time.	1	2	3	4	5	6	7
Our customers tend to look for new products all the time.	1	2	3	4	5	6	7
We are witnessing demand for our products and services from customers who never bought them before.	1	2	3	4	5	6	7
New customers tend to have product-related needs that are different from those of our existing customers.	1	2	3	4	5	6	7
We cater to many of the same customers that we used to in the past.	1	2	3	4	5	6	7

In our industry:	Strongly Disagree						Strongly Agree
The technology in our industry is changing rapidly.	1	2	3	4	5	6	7
Technological changes provide big opportunities in our industry.	1	2	3	4	5	6	7
A large number of new product ideas have been made possible through technological breakthroughs in our industry.	1	2	3	4	5	6	7
Technological developments in our industry are rather minor.	1	2	3	4	5	6	7

	Strongly Disagree						Strongly Agree
Changes in the marketing practices of our competitors are easy to predict.	1	2	3	4	5	6	7
The actions of our competitors are easy to predict.	1	2	3	4	5	6	7
Demand and consumer preferences are easy to predict.	1	2	3	4	5	6	7
Changes in product technology within this industry are easy to predict.	1	2	3	4	5	6	7

FIRM PERFORMANCE

For new-product development (NPD) projects your business unit worked on during the past three years, what is the:

Approximate Return on Investment (ROI - for the new product development program) _____
Approximate percentage of business unit's profits from new products _____
Approximate percentage of business unit's sales from new products _____
Approximate percentage of NPD projects the business unit considers as success _____

	Never						All the time
What is the degree to which NPD projects lead to future opportunities?	1	2	3	4	5	6	7

	Very Unsuccessful						Very Successful
What is the overall success of the NPD program, in management's opinion:	1	2	3	4	5	6	7

	Never						All the time
What is the degree to which front-end of innovation activities lead to future opportunities?	1	2	3	4	5	6	7

	Very Unsuccessful						Very Successful
What is the overall success of front-end of innovation activities, in management's opinion:	1	2	3	4	5	6	7

Please respond to the following questions for NPD projects your business unit worked on during the past three years:	A Great Failure						A Great Success
Relative to your business unit's objectives, how successful has the NPD program been in terms of profits.	1	2	3	4	5	6	7
Relative to your business unit's objectives, how successful has the NPD program been in terms of sales.	1	2	3	4	5	6	7
Relative to your business unit's objectives, how successful has the NPD program been in terms of market share.	1	2	3	4	5	6	7

Please respond to the following questions for NPD projects your business unit worked on during the past three years:	A Great Failure						A Great Success
Relative to your major competitors, how successful has the NPD program been in terms of profits.	1	2	3	4	5	6	7
Relative to your major competitors, how successful has the NPD program been in terms of sales.	1	2	3	4	5	6	7
Relative to your major competitors, how successful has the NPD program been in terms of market share.	1	2	3	4	5	6	7

DEMOGRAPHIC QUESTIONS

How long have you been employed in your current industry? _____ years _____ months

How long have you been employed with your current firm? _____ years _____ months

How long have you been involved in innovation activities in your career? _____ years _____ months

How long have you been involved in innovation activities with your firm? _____ years _____ months

Approximately how many new-product projects have you been involved in:

During your career? _____
During your time with your current firm? _____

What are the approximate annual sales of your firm?

- ❍ Less than $500,000
- ❍ Between $500,000 and $999,999
- ❍ Between 1 million and 10 million US Dollars
- ❍ Between 10 million and 50 million US Dollars
- ❍ Between 50 million and 100 million US Dollars
- ❍ Between 100 million and 500 million US Dollars
- ❍ Between 500 million and 1 billion US Dollars
- ❍ Between 1 billion and 10 billion US Dollars
- ❍ Between 10 billion and 50 billion US Dollars
- ❍ Over 50 billion US Dollars

What is the approximate number of employees in your firm?

- ❍ Less than 25 employees
- ❍ Between 25 and 100 employees
- ❍ Between 101 and 200 employees
- ❍ Between 201 and 500 employees
- ❍ Between 501 and 800 employees
- ❍ Between 801 and 1000 employees
- ❍ Between 1001 and 5000 employees
- ❍ Over 5000 employees

How long has your firm been in business? _____ years

For how many years has your firm operated in the current industry? _____ years

Just one last thing.

In order to assist the researchers in their analysis of this research study, it would be helpful if you would kindly type the name of the company you work for in the space below.

Company Name _____

You may click next if you wish not to divulge this information.

Thank You!

CONCLUSION STATEMENT

WE THANK YOUR FOR YOUR PARTICIPATION AND GREATLY APPRECIATE YOUR SUPPORT OF OUR RESEARCH.

APPENDIX C

REGRESSION EQUATIONS

Regression Equations Main Effects Model

(1) $\text{FPS} = \alpha + \beta_1\text{DMC} + \beta_2\text{CAPI} + \epsilon$

(2) $\text{CAPI} = \alpha + \beta_1\text{ICL} + \epsilon$

(3) $\text{DMC} = \alpha + \beta_1\text{AA} + \epsilon$

(4) $\text{AA} = \alpha + \beta_1\text{PCOMP} + \beta_2\text{FNE} + \epsilon$

Regression Equations for Full Model

(1) $\text{FPS} = \alpha + \beta_1\text{DMC} + \beta_2\text{CAPI} + \epsilon$

(2) $\text{CAPI} = \alpha + \beta_1\text{ICL} + \epsilon$

(3) $\text{DMC} = \alpha + \beta_1\text{AA} + \epsilon$

(4) $\text{AA} = \alpha + \beta_1\text{PCOMP} + \beta_2\text{FNE} + \beta_3\text{ICL} + \beta_4(\text{PCOMP}\times\text{ICL}) + \beta_5(\text{FNE}\times\text{ICL}) + \epsilon$

Regression Equations for Full Model with Covariate Added

(1) $\text{FPS} = \alpha + \beta_1\text{DMC} + \beta_2\text{CAPI} + \epsilon$

(2) $\text{CAPI} = \alpha + \beta_1\text{ICL} + \epsilon$

(3) $\text{DMC} = \alpha + \beta_1\text{AA} + \epsilon$

(4) $\text{AA} = \alpha + \beta_1\text{PCOMP} + \beta_2\text{FNE} + \beta_3\text{ICL} + \beta_4(\text{PCOMP}\times\text{ICL}) + \beta_5(\text{FNE}\times\text{ICL}) + \beta_6\text{YT3} + \epsilon$

Regression Equations for Revised Model

(1) $\text{FPS} = \alpha + \beta_1\text{DMC} + \beta_2\text{CAPI} + \epsilon$

(2) $\text{CAPI} = \alpha + \beta_1\text{ICL} + \epsilon$

(3) $\text{DMC} = \alpha + \beta_1\text{PCOMP} + \beta_2\text{FNE} + \beta_3\text{ICL} + \beta_4(\text{PCOMP}\times\text{ICL}) + \beta_5(\text{FNE}\times\text{ICL}) + \epsilon$

APPENDIX D

PREACHER AND HAYES MEDIATION AND MODERATION TESTS

Relevant cites:

Hayes, Andrew F. (2013), *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach*. New York, NY: Guilford Publication.

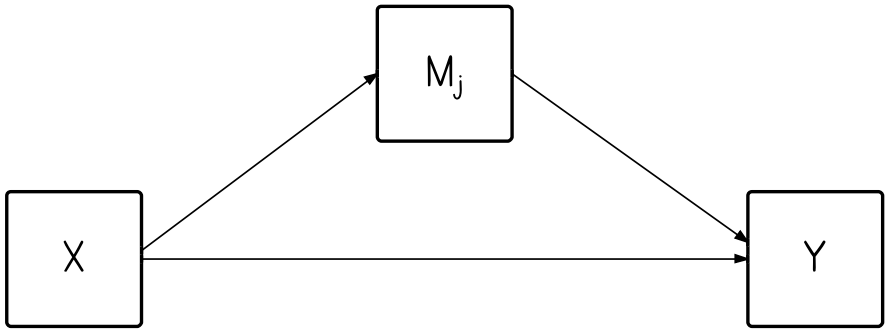
Hayes, Andrew F., "*Process: A Versatile Computational Tool for Observed Variable Mediation, Moderation, and Conditional Process Modeling*." Manuscript submitted for publication (2012).

Zhao, Xinshu, John G Lynch, and Qimei Chen (2010), "Reconsidering Baron and Kenny: Myths and Truths About Mediation Analysis," *Journal of Consumer Research*, 37 (2), 197-206.

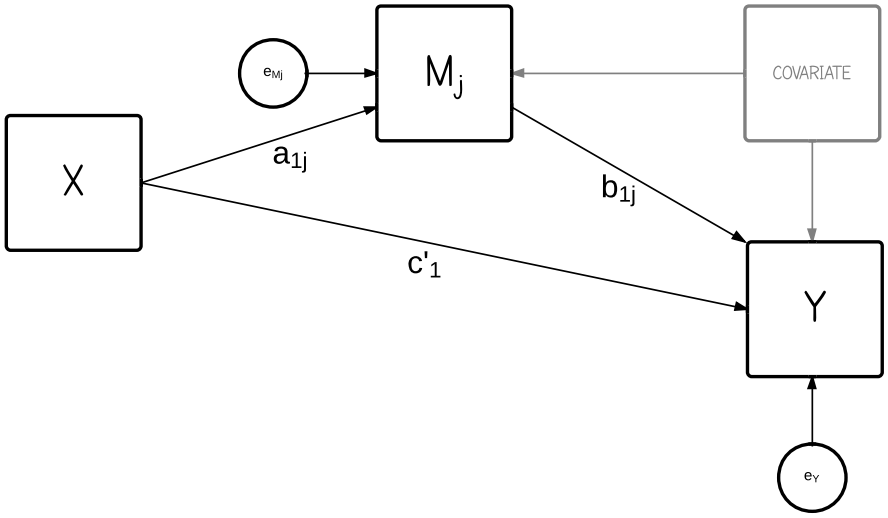
Preacher, KristopherJ and AndrewF Hayes (2004), "Spss and Sas Procedures for Estimating Indirect Effects in Simple Mediation Models," *Behavior Research Methods, Instruments, & Computers*, 36 (4), 717-31.

Preacher and Hayes Model 4.

Conceptual Model



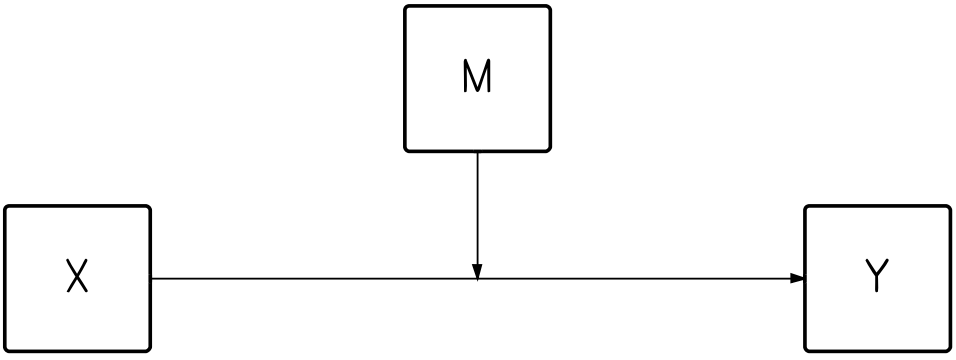
Statistical Model



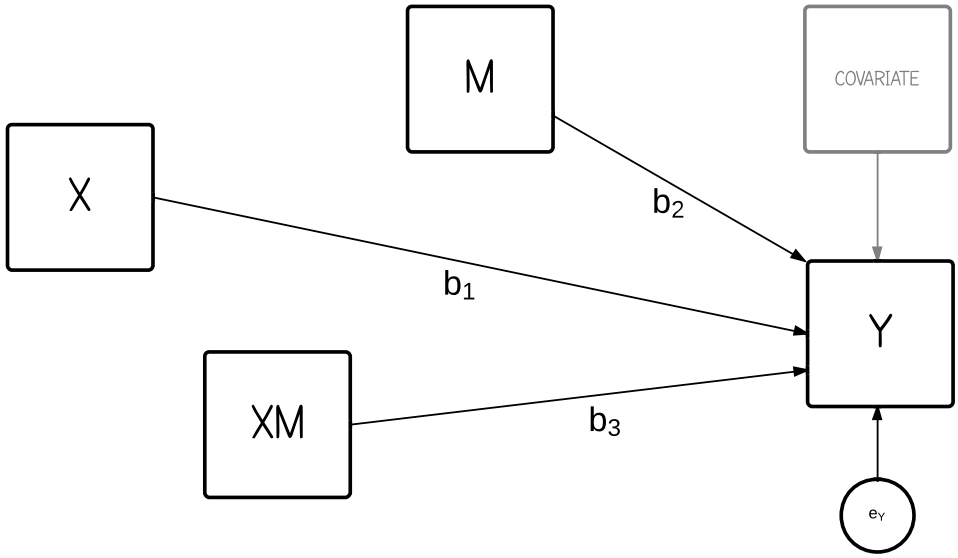
Indirect effect of X on Y through $M_j = a_{1j}b_{1j}$
Total indirect effect of X on Y through all M = $\Sigma_j (a_{1j}b_{1j})$
Direct effect of X on Y = c'_1

Preacher and Hayes Model 1.

Conceptual Model



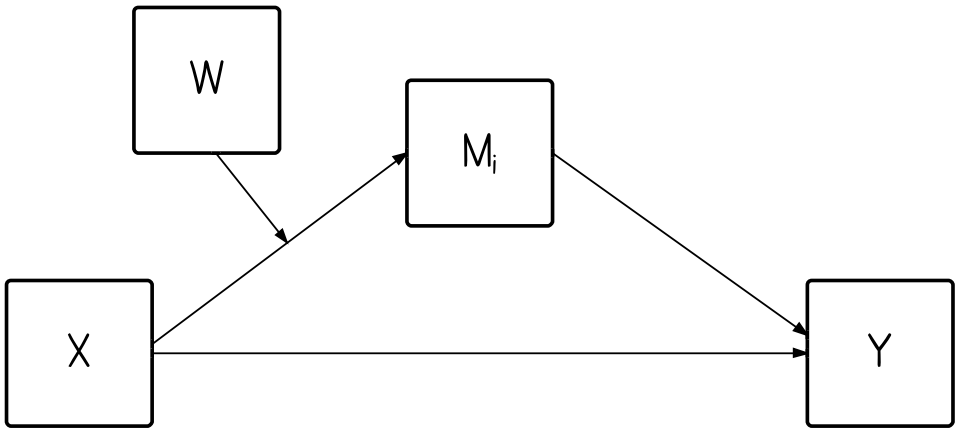
Statistical Model



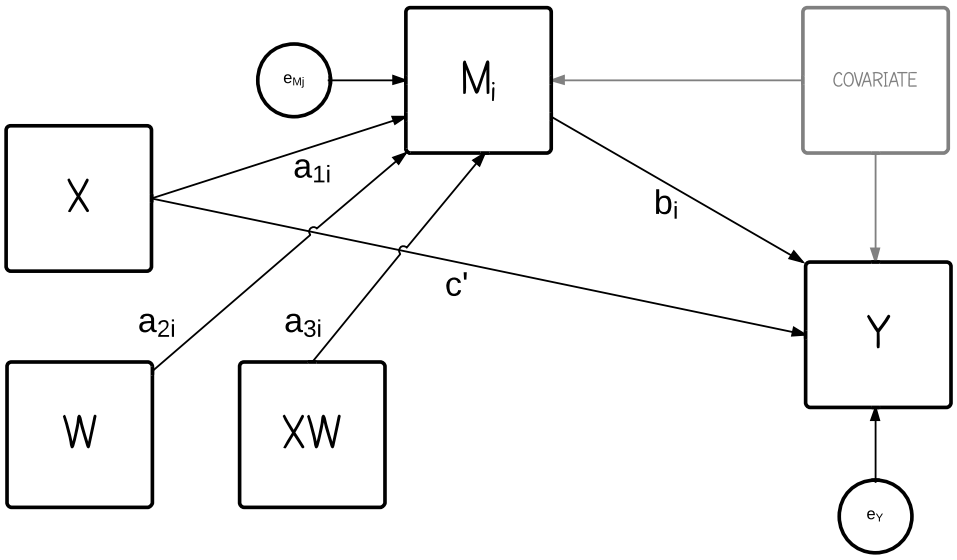
Conditional effect of X on $Y = b_1 + b_3M$

Preacher and Hayes Model 7.

Conceptual Model



Statistical Model



Conditional indirect effect of X on Y through $M_i = (a_{1i} + a_{3i}W)b_i$
Direct effect of X on Y = c'

APPENDIX E

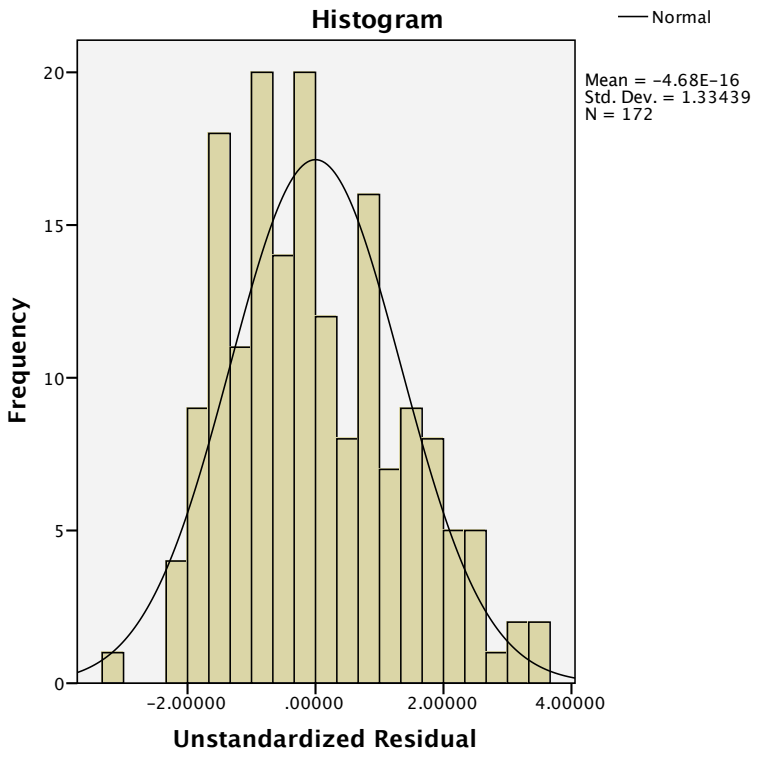
REGRESSION ASSUMPTION TESTS (OUTPUT)

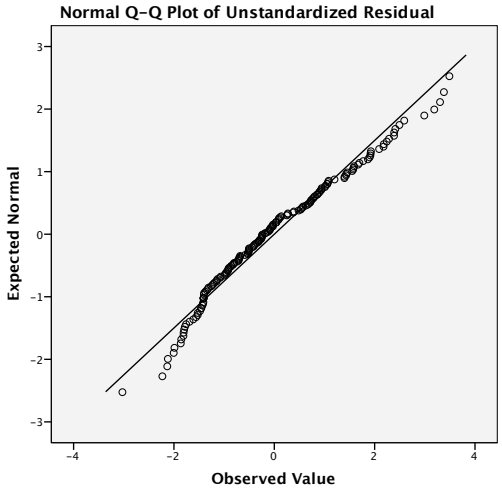
Tests of Normality for Ambiguity Aversion Measure

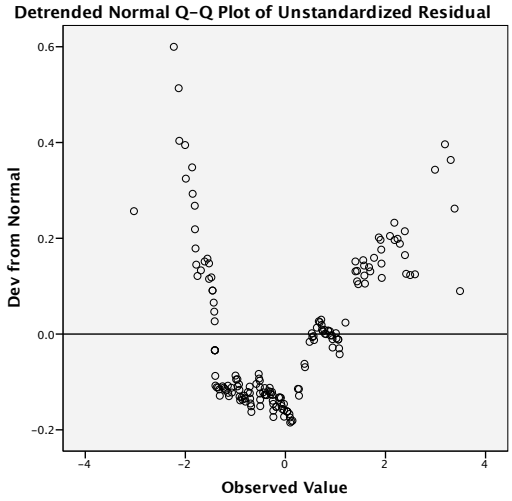
Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Unstandardized Residual	.076	172	.016	.972	172	.002

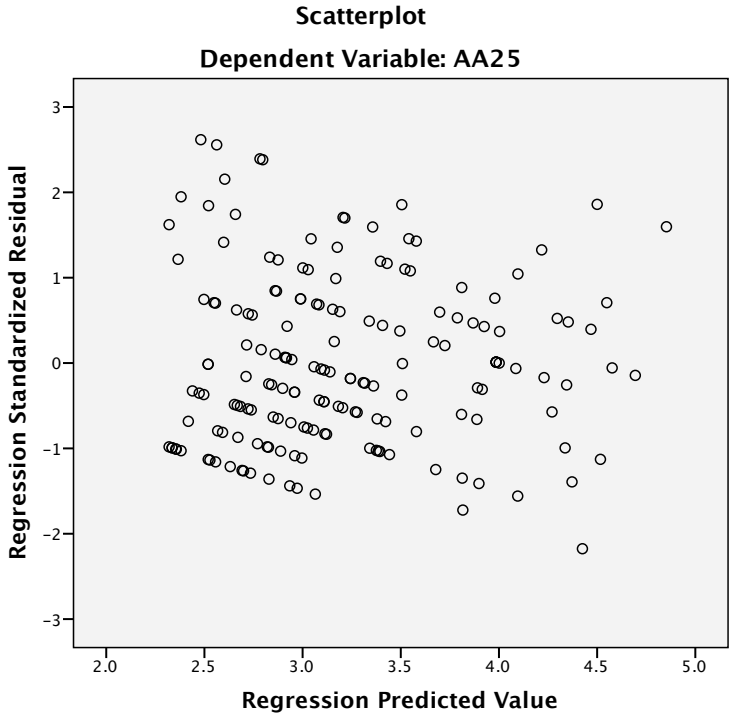
a. Lilliefors Significance Correction







Tests of Hetersocedasticity for Ambiguity Aversion Measure



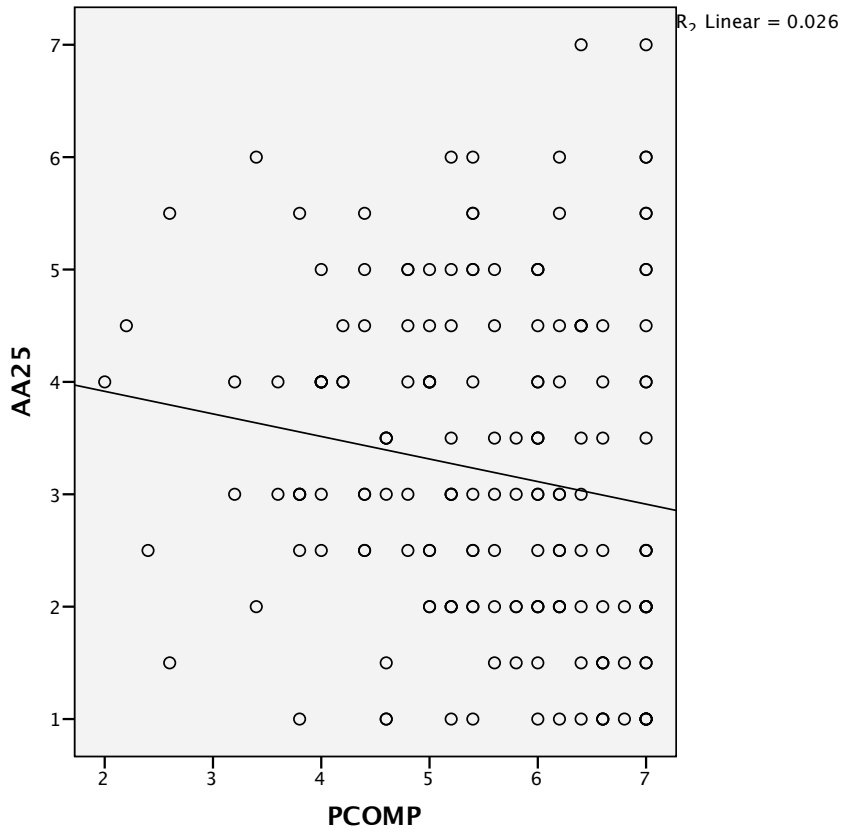
Tests of Collinearity for Ambiguity Aversion Measure

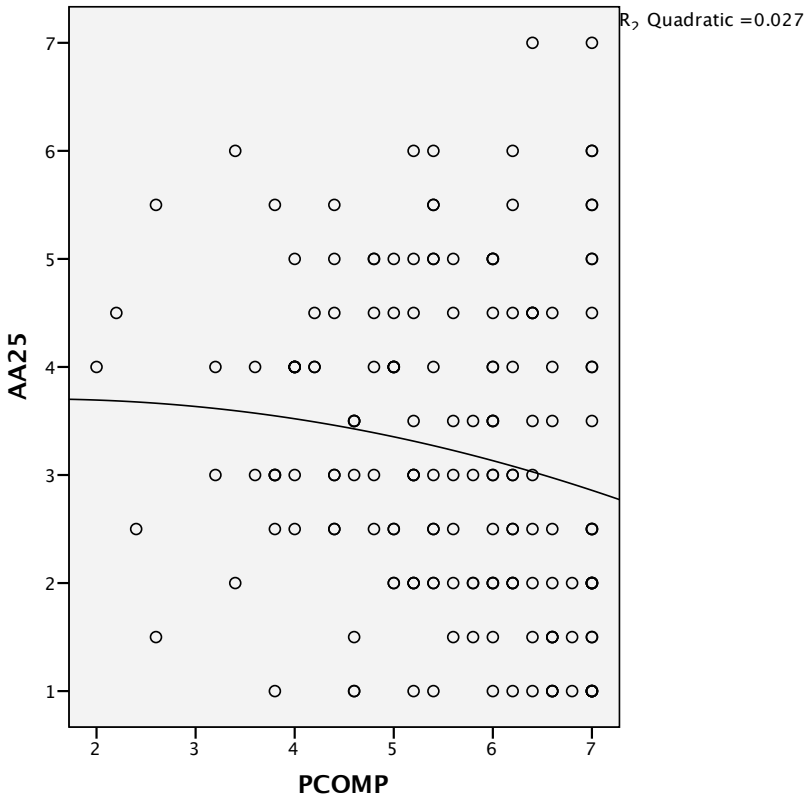
Coefficients[a]

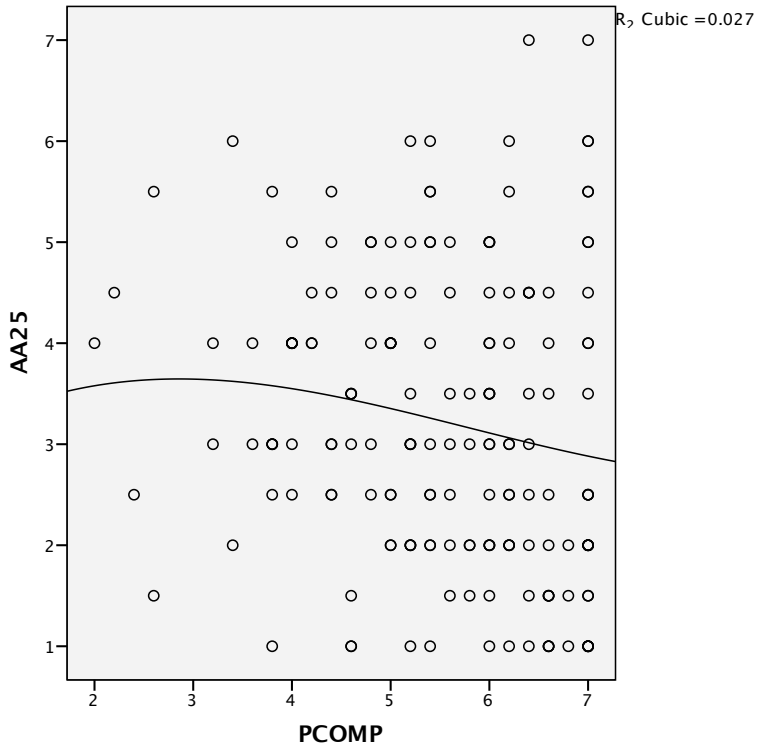
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.992	.624		4.791	.000		
	PCOMP	-.092	.097	-.074	-.956	.341	.832	1.203
	FNE	.402	.075	.382	5.350	.000	.969	1.032
	ICL	-.061	.093	-.050	-.658	.511	.855	1.169

a. Dependent Variable: AA25

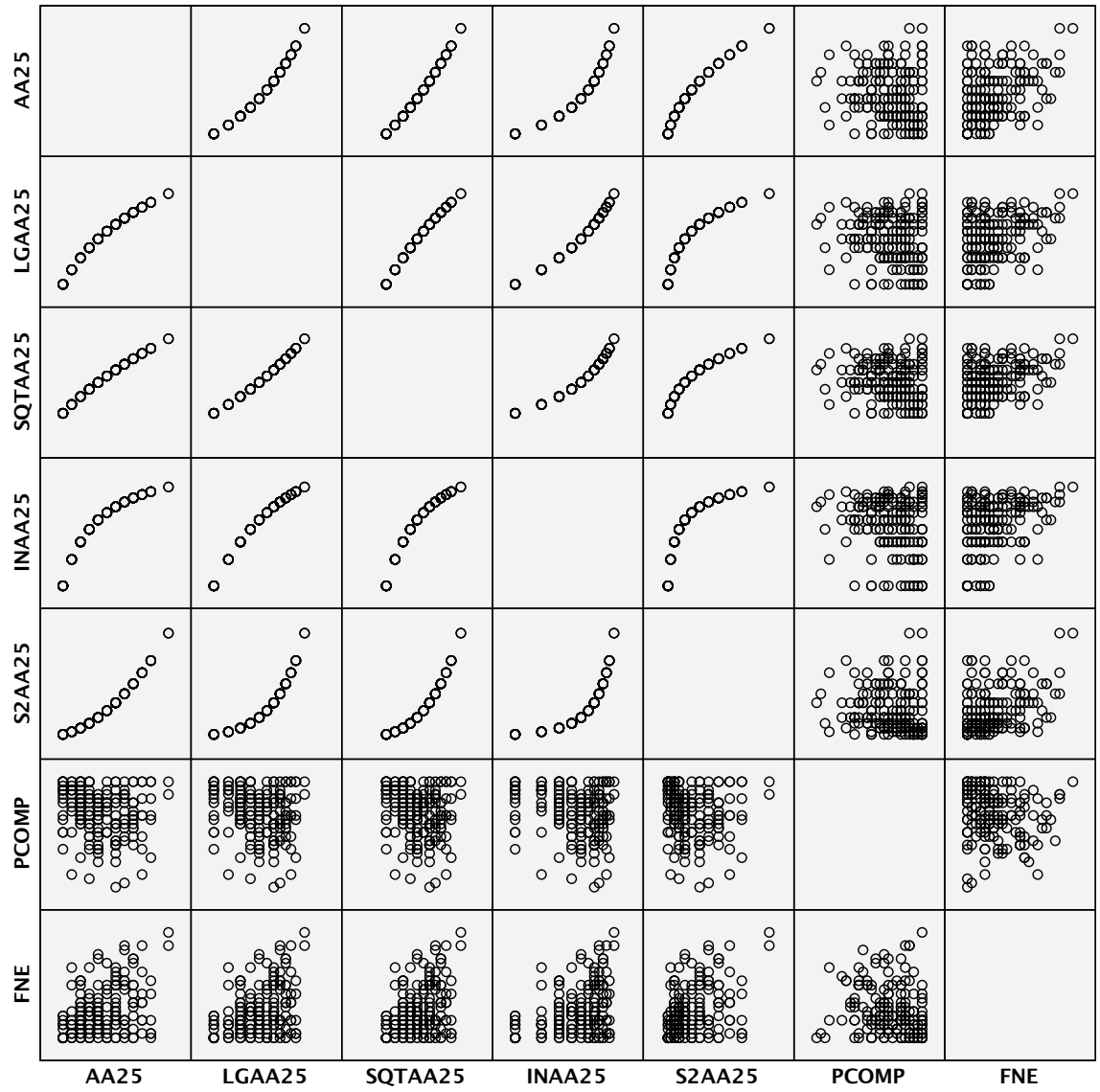
Tests of Linearity for Ambiguity Aversion Measure




R2 Quadratic =0.027
AA25
PCOMP
1
2
3
4
5
6
7


R2 Cubic =0.027
AA25
PCOMP
1
2
3
4
5
6
7

Linearity for Ambiguity Aversion Measure after various transformations



AA25 – Ambiguity Aversion
LGAA25 – Log transformation of ambiguity aversion
SQTAA25 – Square root transformation of ambiguity aversion
INAA25 – Inverse transformation of ambiguity aversion
S2AA25 – Squared transformation of ambiguity aversion

PCOMP – Perceived Competence
FNE – Fear of Negative Evaluation

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