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# The Relationship Between External Turbulence and New Product Development Practices

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# THE RELATIONSHIP BETWEEN EXTERNAL TURBULENCE AND NEW PRODUCT DEVELOPMENT PRACTICES

By
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by
Michael W. Maxwell

We hereby certify that this Dissertation submitted by Michael W. Maxwell conforms to acceptable standards, and as such is fully adequate in scope and quality. It is therefore approved as the fulfillment of the Dissertation requirements for the Degree of Doctor of Business Administration.

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# ABSTRACT


THE RELATIONSHIP BETWEEN EXTERNAL TURBULENCE AND NEW PRODUCT DEVELOPMENT PRACTICES

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This dissertation considered whether new product development practices employed resolved the uncertainty and equivocality in information processing created by external turbulence. With external turbulence coming from more sources and arriving with greater frequency, this wave of change must be addressed to achieve desired project outcomes.

Healthcare was the target industry for this research and respondents were selected from members of HIMSS, the Healthcare Information Management Systems Society. Five hundred sixty-three survey responses were collected about completed new product development projects. The aspects of the projects reported included the external turbulence experienced, flexible new product development practices employed, the effectiveness of information processing and the project's outcomes.

The results using all respondents did not show support for the crucial hypothesis that reduction of uncertainty and equivocality in the information processing environment leads to desired new product development outcomes.

While the full respondent set did not support the main hypothesis, the subset of projects that were completed during the ramp-up of the Affordable Care Act showed the hypothesized relationship. With the Affordable Care Act ramp-up, there was a wave of change and a high volume of new information generated by external turbulence. Those organizations that were successful used their information processing capabilities to reduce uncertainty and equivocality and address the changes. Their information processing capability combined with flexible product development practices was directly related to positive new product development outcomes. The extreme example of external turbulence that occurred during the Affordable Care Act ramp-up supported the crucial hypothesis about information processing.

The research also found that external turbulence is related to the positive use of flexible new product development practices and that use of those practices is directly related to desired new product development outcomes. In the presence of external turbulence, product development teams use flexible new product development practices to achieve desired project outcomes.

The major implication from this study is the need by product development teams to consider external turbulence as a factor in all product plans. It was the strongest relationship reported.

*Keywords*: innovation, turbulence, uncertainty, equivocality, agile development, foundational customers, early feedback, late decision making, supplier involvement, technological turbulence, market turbulence, competitive turbulence, regulatory turbulence, economic turbulence

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## Research Problem

How do nations maintain a global competitive advantage and enjoy the prosperity that follows?

## Introduction

According to Porter (1990), a nation's competitive advantage is dependent on its industry's ability to innovate. National competitive advantage and the wealth it creates originates from the aggregated benefit of innovation activities carried out across all firms. Management theorists submit that the central goal of business is the development of innovative products that generate growth, lift employment levels and are accessible to an increasingly wide range of the world's population (Ahlstrom, 2010; Baumol & Strom, 2007).

### Nations thrive from innovation

Nations thrive if their businesses innovate, but what is innovation? Gordon Brunner, Procter and Gamble's chief technology officer for thirteen years, describes innovation as the marriage of "what's needed" in the market with "what's possible" in the lab (Brunner, 2001). His model for this successful marriage identifies product development processes employed as the crucial ingredient.

While Brunner's definition is from the popular press, it is also echoed in the literature. Innovation is the tendency of an organization to develop new or improved products/services and its success in bringing those products/services to the market (Damanpour & Evan, 1984; Gopalakrishnan & Damanpour, 1997; Gumusluoglu & Ilsev, 2009; Jimenez-Jimenez, Valle, & Hernandez-Espallardo, 2008).

**Innovation requires capable new product development processes**

It follows that successful innovation is dependent upon the new product development processes employed. Therefore, new product development processes employed are fundamental to a firm's competitive advantage and, in aggregate, crucial to maintaining a nation's competitive advantage and the prosperity it generates for the citizenry (Harris & Mowery, 1990; Lyon & Ferrier, 2002; Scherer, 1992). Any improvement in those processes can improve a firms' competitive advantage and its country's prosperity.

In the ongoing globalization of markets, new product development processes can be disrupted by the external turbulence experienced by the organization (Bstieler, 2005; Buganza, Dell-Era, & Verganti, 2009; Calantone, Garcia, & Dröge, 2003; Cummings, Blumenthal, & Greiner, 1983; Jimenez-Jimenez et al., 2008; Saemundsson & Candi, 2013; Tellis, 2006). A common dictionary definition describes external turbulence as a state of confusion characterized by unpredictability and uncontrolled change (Merriam-Webster, 1983). In the literature, external turbulence is defined as the accelerating rate and complexity of interactive events in an organization's external environment (Duncan, 1972; Huber, O'Connell, & Cummings, 1975; Terreberry, 1968). Examples of external turbulence are unexpected competitor actions, rapidly changing customer preferences, sudden transformation in enabling technologies and significant regulatory events.

**External turbulence disrupts with an overload of new information**

External turbulence disrupts new product development processes. The new product development processes used by many organizations are based upon experiential evidence from recent years (Brown & Eisenhardt, 1995). In stable (non-turbulent) external environments, information gathering is a repetitive "learning-by-doing" exercise and searching for knowledge only occurs when the firm lacks the knowledge it needs internally (Akgün, Lynn, & Byrne, 2006; Johanson & Johanson, 2006). External turbulence, by its definition, upsets those experience based processes (Brown & Eisenhardt, 1995; Buganza et al., 2009; Calantone, Harmancioglu, & Droge, 2010; Pradip N. Khandwalla, 1973) by generating a wave of changes and an overload of new information that nullifies existing product plans, upsets control mechanisms and freezes new product development activities (Antoniou, Pescetto, & Stevens, 2007; Atuahene-Gima, 1995; Bourgeois III & Eisenhardt, 1988; Calantone et al., 2010; Covin & Slevin, 1989; Iansiti, 1995; D. Miller & Friesen, 1982; Song, Xie, & Di Benedetto, 2001).

**Firms in turbulent markets using normal routines learn little**

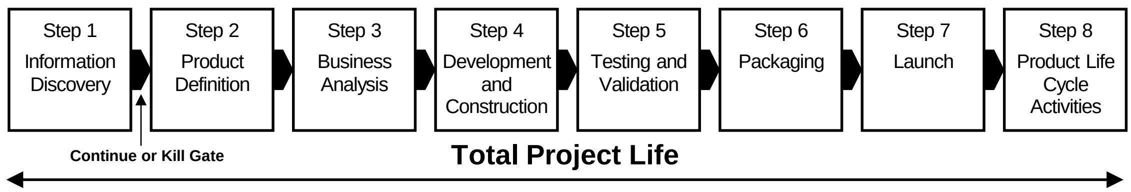
Firms in turbulent markets using their internally focused routines generally learn little about the turbulence driven changes and only make discoveries that relate to the status quo (Michael & Palandjian, 2004). New product development processes that previously made sense of product opportunities are overwhelmed by the changes

(Calantone et al., 2010; Calantone, Schmidt, & Di Benedetto, 1997) and cannot unravel the transformation in the external environment (Bstieler, 2005; Calantone et al., 2003; Carson, Wu, & Moore, 2012; Souder, Sherman, & Davies-Cooper, 1998). To be successful, new product teams must address difficult and hard-to-forecast changes that result from external turbulence (Bstieler, 2005; Cummings et al., 1983). The challenge is seeing into the external turbulence and analyzing it in terms of alternative courses of action, costs, benefits, and outcomes (Daft & Macintosh, 1981). By definition, this state of confusion raises doubt, heightens insecurity and leads to hesitation in making decisions (Merriam-Webster, 1983).

**New product development processes can fail to address change**

To recap, new product development processes that are crucial to prosperity can fail in the presence of external turbulence. The failure is caused by the inability of information processing within those processes to resolve confusion about the external environment and translate the wave of new information into successful product actions. Much of the failure has been attributed to the sequential nature of traditional new product development processes (Bhattacharya, Krishnan, & Mahajan, 1998; Bstieler, 2005; Buganza et al., 2009; Buganza, Gerst, & Verganti, 2010; Buganza & Verganti, 2006; Cordero, 1991; Gold, 1987; Iansiti & MacCormack, 1997; Kessler & Chakrabarti, 1999; Mabert, Muth, & Schmenner, 1992; MacCormack & Verganti, 2003; MacCormack, Verganti, & Iansiti, 2001; Millson, Raj, & Wilemon, 1992; Song & Montoya-Weiss, 2001; Wind & Mahajan, 1997). Traditional new product development process models, as typified by the Cooper (1990) Stage-Gate model, are composed of discrete sequential steps with a "continue or kill" decision made at the end each step. The steps are formal with each step settling a certain aspect of the new product proposal before the next step begins (see figure 1). In stable (non-turbulent) external environments, a structured sequential process methodology has been shown to be effective but has been found to fail in environments with high external turbulence because of the lack of flexibility.

*Figure 1: Traditional sequential new product development process (Derived from Iansiti, 1997)*




Traditional processes have no mechanism to go back to a previous step or take a different path in order to incorporate the wave of new information generated by the external turbulence.

**Flexibility prescribed to counteract external turbulence**

To address the shortcomings of traditional product development processes in turbulent environments, many new steps and tactics have been proposed that add flexibility to the traditional sequential product development methodologies (Biazzo, 2009; Eling, Griffin, & Langerak, 2013; J. Kim & Wilemon, 2002; Rahman, Rahim, Shariff, & Baksh, 2003; Shamsuzzoha, Kyllönen, & Helo, 2009; Shankar, Acharia, & Baveja, 2009; Sung-Wook & Soo-Wook, 2010; Thomke & Reinertsen, 1998). They include agile methodologies, late decision making, early feedback through prototyping, integrative practices for rebuilding knowledge and others.

While much research has been performed on flexible tactics, they have not been analyzed on their ability to process the considerable amount of new information coming from external turbulence.  Since the failure to address the wave of changes and overload of information is the fundamental shortcoming of traditional sequential new product development processes in the presence of external turbulence, understanding the flexible replacement processes' ability to handle information is important to the development of successful new products.  This research addresses whether flexible processes overcome the information processing failures that overwhelms traditional new product development processes in turbulent environments.

**Use theory of organizational information processing to assess**

To perform this research, a structure is needed to assess the information processing occurring in new product development processes.  Daft and Lengel (1986) developed a theory of organizational information processing to evaluate how firms cope with information processing under difficult conditions such as external turbulence.  The application of this theory to new product development continues the work of Hong, Nahm, and Doll (2004), Koufteros, Vonderembse, and Doll (2002) and Zhang and Doll (2001).

Daft and Lengel (1986) partitioned information processing under difficult conditions (e.g. external turbulence) into two often competing challenges – information uncertainty and equivocality.  Uncertainty is the lack of information about the external environment and equivocality indicates that multiple disparate interpretations exist for the external environment.

In this application, the theory models how flexible product development processes can reduce uncertainty and resolve equivocality. It follows that the theory of information processing from Daft and Lengel (1986) provides a structure to consider the ability of flexible processes to address the wave of changes and overcome the information overload that overwhelms traditional new product development processes.

**Problem and Sub-Problems**

Do flexible new product development practices resolve the uncertainty and equivocality in processing information that is created by external turbulence?

Sub questions are:

(a) What is the impact of external turbulence on uncertainty and equivocality in information processing?

(b) What flexible internal product development practices resolve uncertainty and equivocality in information processing?

(c) How does information processing, when measured by uncertainty and equivocality, affect product development outcomes?

**Background and Justification**

While external turbulence has always been part of the new product development literature, the research has not directly addressed the challenges of information processing in the presence of external turbulence. This research aspires to fill that gap.

**Global competition created initial interest**

It was external turbulence created by the intensification of global competition in the 1980's that drove the consideration of new product development processes in the literature (Little, 1984; Little, Crawford, & Crisp, 1984). The march towards globalization during this period exposed previously protected domestic businesses to the rigor of world-wide competition (Koten, 1987). In addition, the deregulation of domestic markets that was popular in many countries generated substantial turbulence for the incumbents – US telecommunication (1984), US airlines (1978) US trucking (1980), UK busses 1980, UK telecom (1984), and others (OECD, 1990).

The early debate was whether firms needed an over-arching product development strategy and, if so, what type (Little, Holt, Till, Voss, & Wind, 1984). Was it better to use a technology push or a market pull strategy (Cooper, 1984)? A technology push strategy was the de rigueur strategy of the day, driven by manufacturing and effective in protected domestic markets. It creates products using the organization's best available technology and assigns the marketing function with the responsibility to sell them. A market pull strategy represented the leading edge of new product development and was intended to address the global competition that was coming from all directions. In a market pull strategy, a market analysis is applied, and products are created to satisfy the significant market requirements identified.

**Initial research was inward**

Despite general agreement that the external environment should be taken into consideration, the literature rarely analyzed external turbulence (Bstieler, 2005; Wind & Mahajan, 1997). The literature argued that familiarity with the products and markets along with organizational experience were the antecedents to new product success

(Montoya-Weiss & Calantone, 1994; Moorman & Miner, 1997; Varadarajan, 1983). The pervasive aphorism was "Stick to your core competencies to ensure success."

The sequential new product development processes previously described came out of that stream of research (Wind & Mahajan, 1997). The original intention of the sequential processes was to serve as a funnel that screens out new product ideas, concepts, and products that do not meet some a priori criteria or that seem too risky.

In some of the early research, a few researchers considered the effects of fast changing markets and technologies on new product development processes. Researchers included Cooper and Kleinschmidt (1993), Eisenhardt and Tabrizi (1995), Song and Montoya-Weiss (2001) and Tatikonda and Montoya-Weiss (2001), but their results were presented as a special case of traditional sequential product development processes (Bstieler, 2005; Buganza et al., 2009). They posited that special case treatment may be needed due to the industry involved such as Internet commerce or because of a unique geography such as Australia. The traditional sequential new product development processes were still recommended for all other situations.

To solve those special cases, the addition of process flexibility was the prescription, Iansiti (1995), Iansiti and MacCormack (1997), Bhattacharya et al. (1998), Verganti (1999) and Massini, Lewin, Numagami, and Pettigrew (2002). However, flexibility was not considered to be a superior alternative to the sequential new product development processes, but a trade-off against the quality of the product to be delivered (Buganza et al., 2009). It was theorized that as a sequential methodology moves to a flexible methodology, product quality would suffer.

**External turbulence increases**

As economies continued the move from a regional bias to a global basis, external turbulence originated from multiple sources and arrived with greater frequency thereby affecting a steadily increasing number of industries (Naik, 2008; Scheck & Glader, 2009; Whitehouse & Aeppel, 2009). Traditional sequential new product development processes were having greater difficulty surviving the Schumpeterian world where firms must cope with high velocity change in managing their collection of products and services (Calantone et al., 2003; Dayan & Elbanna, 2011; Jimenez-Jimenez et al., 2008; MacCormack et al., 2001; Song & Montoya-Weiss, 2001; Tatikonda & Montoya-Weiss, 2001).

While the prevalence of external turbulence led to additional questioning of sequential new product development processes, the research had shortcomings. First, the research recognized that information gathering is important, but did not directly evaluate new product development processes in that light. The research considered factors around information processing such as product newness, team experience, technological novelty, design proficiency and other attributes (MacCormack et al., 2001; Song & Montoya-Weiss, 2001; Tatikonda & Montoya-Weiss, 2001), but not the ability to process information. This research evaluates how the tactics intended to provide flexibility in new product development can process the information that comes from the wave of changes and overload of new information generated by external turbulence.

Second, most research on new product performance evaluated a single factor versus a more broad based approach that considered the relative effect of various factors (Montoya-Weiss & Calantone, 1994). This research is expected to evaluate multiple tactics intended to add flexibility to new product development against a broad range of external turbulence categories.

This dissertation will contribute to the literature by using the theory of organizational information processing to determine if the new flexible new product development tactics proposed can counteract the effects of external turbulence. Effective new product development processes are an antecedent to successful innovation; a robust portfolio of innovation leads to national competitiveness; and a nation's global competitive advantage leads to improved outcomes and the wealth needed to create a better society.

## Definitions

The following definitions describe the variables used in this dissertation's research model. The model is found on page 79.

### External turbulence

External turbulence is the accelerating rate and complexity of interactive events in an organization's external environment and the effects of those turbulent events on the organization's ability to process information (Duncan, 1972; Huber et al., 1975; Terreberry, 1968).

The kinds of external turbulence considered in this dissertation are:

***Technological turbulence.*** Technological turbulence is the rate of technological change (Calantone et al., 2003; Jaworski & Kohli, 1993).

***Market turbulence.*** Market turbulence is the rate of change in customer preferences (Jaworski & Kohli, 1993).

***Competitive turbulence.*** Competitive turbulence considers the ability of competitors to thwart a firm's market actions (Jaworski & Kohli, 1993).

***Regulatory turbulence.*** Regulatory turbulence is high regulatory fluctuation and stringency (Wijen & Van Tulder, 2011).

**Product development practices**

Product development practices are the disciplined and defined set of tasks, steps and phases that describe the normal means by which a company repetitively converts embryonic ideas into salable products or services (Kahn, 2004).

The product development practices included in this research are flexible practices expected to counteract the effects of external turbulence. They are grouped in two categories – process speed and integrative practices.

**Process speed**

Process speed refers to the compression of activities (Eisenhardt & Tabrizi, 1995) versus traditional sequential new product development practices. For this research, agile development, early feedback and late decision making are the product development practices used to speed the product development process:

***Agile development.*** Agile development is characterized by rapid development iterations to gain feedback combined with overlapping processes where the next iteration begins before the current iteration finishes (Mohan, Ramesh, & Sugumaran, 2010; Zhang

& Doll, 2001). Agile development is in contrast to the traditional waterfall development methodology that focuses on preparing a complete and detailed design specification before the execution / construction phase begins (Guntamukkala, Wen, & Tarn, 2006).

***Early feedback.*** Early feedback refers to regularly gathering feedback from multiple constituents at the earliest stages of the product development process (Buganza et al., 2009; Lakemond, Magnusson, Johansson, & Säfsten, 2013; Narasimhan, Swink, & Kim, 2006).

***Late decision making.*** In late decision making, product concepts, capabilities and designs are not frozen until the last phases of the development / construction process (Buganza et al., 2009; Buganza et al., 2010). Late decision making is in contrast to the traditional stage gate style processes where product development is divided into a sequential structure of decision gates (Kahn, 2004). At each decision gate, a facet of the product is agreed and frozen before the process moves to the next gate.

## Integrative practices

Integrative practices are the processes used by the organization to regenerate its knowledge base (Eisenhardt & Martin, 2000; Kogut & Zander, 1992; Marsh & Stock, 2006). For this research, the integrative practices included are foundational customers and supplier participation.

***Foundational customers.*** Foundational customers are customer representatives who participate in the new product development process and in a manner that helps shape the requirements (Carbonell, Rodríguez-Escudero, & Pujari, 2009; Gatignon & Xuereb, 1997).

***Supplier participation.*** Supplier participation refers to the roles that suppliers play in the product development process. It ranges from simply delivering parts based on a specification to substantial involvement in the design process (Cusumano & Takeishi, 1991; Gatignon & Xuereb, 1997; Ragatz, Handfield, & Petersen, 2002).

## Information processing environment

The information processing environment is the portion of the new product development process that handles the two opposing states of uncertainty and equivocality (Daft & Lengel, 1986). It is the wave of changes and overload of new information generated by external turbulence that leads to uncertainty and equivocality in information processing within new product development processes.

***Uncertainty.*** Uncertainty is the absence of information and, in the context of new product development, the difference between the information required to address an issue from the external environment and the information available (Daft & Lengel, 1986).

***Equivocality.*** Equivocality is synonymous with ambiguity. While uncertainty means lack of information, equivocality means there are multiple conflicting interpretations of the information available (Daft & Lengel, 1986; Daft & Macintosh, 1981).

## Product development outcomes

For this research, product development outcomes are defined as the project's actual performance against expectations. Performance categories included are financial performance, market performance and customer satisfaction.

***Financial performance.*** Financial performance is the degree to which the product exceeded or fell short of the expected profitability level (Cooper & Kleinschmidt, 1987).

***Market performance.*** Market performance is the extent to which the product exceeded or fell short of achieving market expectations (Cooper & Kleinschmidt, 1987).

***Customer satisfaction.*** Customer satisfaction is defined as the level of the purchaser's affective response (negative to positive) for the product (Syamil, Doll, & Apigian, 2004).

## Delimitations

### Follows organizations-oriented tradition

This research will follow the organizations-oriented tradition of product development research versus the economics-based lens and the focus on strategy (Brown & Eisenhardt, 1995; Cooper & Kleinschmidt, 1987; Damanpour, 1991). The organizations-oriented tradition considers how product development teams function at the project level and examines micro issues such as the influence that structures, processes, and people have on product development. Generally, questionnaires and interviews gather responses from high-ranking respondents within a project. The questionnaires gather information about why a project succeeded or failed by using a wide spectrum of internal and external factors. The results generated from the research consist of empirically observed correlations.

**Use of the term: innovation**

In this dissertation, the term innovation is rarely used because of its imprecision. Innovation can mean its traditional dictionary definition where an innovation is the act of inventing or introducing something new (Merriam-Webster, 1983) or refer to the topic of innovation theory in the literature.

Unfortunately, there is debate on whether innovation theory is a new predictive theory or the repackaging of the existing literature around bringing new products to market (Krugman, 2014; Lepore, 2014; J. Miller, 2014). Innovation theory detractors posit that innovation theory brings little or nothing new that is instructive about successful new product development but, instead, has added a rhetoric of fear, panic and financial devastation that appeals to the business press. Is the Christensen and Van Bever (2014) definition of disruptive innovation any different from Schumpeter's seventy year old idea of creative destruction and is the Christensen and Van Bever (2014) definition of a sustaining innovation any different from the incremental product improvement that is the proven product launch event in most businesses?

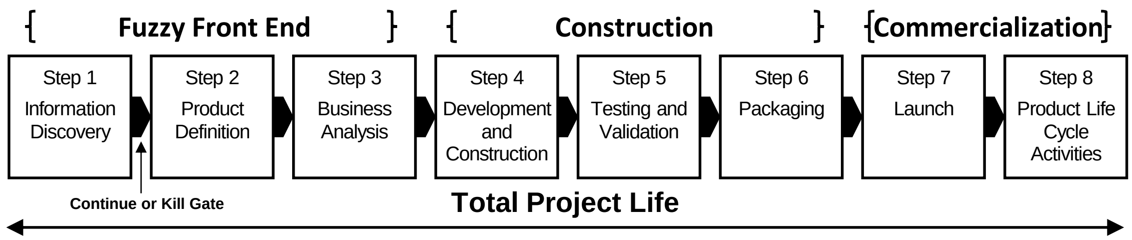
Whether a new product development project delivers a disruptive innovation, a good product or a complete failure, the focus of this research is the new product development processes employed in achieving that result. This research adds to the literature without the need to wade into the innovation theory debate.

**Focus on fuzzy front end processes**

New product development projects that fail generally do so during the fuzzy front end (Khurana & Rosenthal, 1998; Zhang & Doll, 2001). Therefore, this dissertation will focus on new product development processes in the fuzzy front end versus activities in the later stages of the new product development process. Product flops are more often a failure of product and project definition activities in the fuzzy front end versus the inability to develop or construct the product that was contemplated.

Figure 2 shows the new product development process from figure 1 but with labels added for project stages – fuzzy front end, product construction (also called development or engineering depending upon the industry) and commercialization.

*Figure 2: Traditional sequential new product development process with phases (Derived from Iansiti, 1997)*




The fuzzy front end includes the activities leading to the point where either an affirmative or negative decision is made that moves a promising product idea into the more formal product creation methodology of a committed project (Kahn, 2004). Fuzzy is used in describing this period because the product concept is still very fuzzy and the focus is more on "getting started" (Kahn, 2004). Fuzzy front-end tasks are often unstructured and, therefore, appear random, disorderly and erratic versus the formal product development processes that are deliberate, orderly, and predictable. During the fuzzy front end, product strategy, opportunity identification, opportunity analysis, idea generation, product definition, project planning, business case and executive review are addressed (Cooper, 1997; Cooper & Kleinschmidt, 1986; Khurana & Rosenthal, 1998).

**Information processing environment**

In this dissertation, the analysis of the information processing environment is limited to the fuzzy front end processes because of the uniqueness of processes therein.

In the fuzzy front end, information processes are fuzzy and aimed at the discovery of the unknown in the external environment. The goal is addressing the accompanying uncertainty and resolving any equivocality. In the later phases, information processes are internally focused on formalizing the effective collaborative exchange of tacit knowledge among team members (Patnayakuni, Ruppel, & Rai, 2006). So, in comparing the fuzzy front end to later steps, it is fuzzy processes versus formalized processes, an external focus versus internal focus and the act of discovery versus sharing tacit knowledge.

Therefore, information processing in the fuzzy front end is unique to that phase versus the information processing that occurs in the later steps leading to the new product introduction and, as previously stated, it is in the fuzzy front end where new product success or failure is often determined.

## Assumptions

Healthcare is the target industry for all respondents in this research. Specifically, the respondents will be chiefly hospital / provider organizations, healthcare software providers and medical device manufacturers located in North America. It is assumed that the research collected will provide a foundation to extend this research to a broad range of organizations in other industries such as service based offerings, consumer products goods, hospitality, big pharma, capital goods and others.

# CHAPTER II

## Review of Literature

The literature review presented will explore the existing research on the effect of external turbulence on new product development processes in the fuzzy front end. Considerable attention is given to the processes' ability to solve the information processing challenges created by external turbulence and ensure the new product development outcomes are achieved.

This review is performed from the organizations-oriented perspective of product development research. The organizations-oriented perspective considers how product development teams function at the project level and examines micro issues such as the influence that structures, processes, and people have on new product development (Adler, 1989; Ancona & Caldwell, 1992; Brown & Eisenhardt, 1995; Cooper & Kleinschmidt, 1987; Zirger & Maidiquie, 1990). This perspective of studying the actions, characteristics and properties of new product development teams is considered superior in determining the factors the sweep a new product through the market to success (Brown & Eisenhardt, 1995; Cooper & Kleinschmidt, 1987; Damanpour, 1991).

The organization of the literature review aligns with the structure of the research model (page 79) and has four major sections—external turbulence, new product development practices, the information processing environment, and product development outcomes. Each section shows the development of that topic in the literature and its relevance to the research model.

The actions, characteristics and properties of new product development to be addressed within the sections of this literature review include:

- Cross functional teams
- Flexible product development practices
- Integrative product development practices
- Leadership of product development teams
- National culture
- Organizational attributes
- Organizational structure
- Resource based view
- Senior management support
- Sequential product development practices
- Slack resources
- Strategic orientation
- Strategic planning
- Streams of research
- Team learning
- Team psychological factors
- Transactive memory systems

**External Turbulence**

External turbulence is addressed in this section, the first of four sections of this literature review. While external turbulence matters to the success of new product development projects (Bstieler, 2005; Buganza et al., 2009; Calantone et al., 2003; Cummings et al., 1983; Saemundsson & Candi, 2013; Tellis, 2006), the literature has not clearly defined the response by firms to counteract external turbulence. This section of the literature review shows how the existing new product development literature addresses external turbulence and highlights a common thread of information processing challenges.

**External turbulence defined**

External turbulence was first described as the accelerating rate and complexity of novel phenomena occurring frequently in an organization's external environment and the effects of those turbulent events on the organization's operation (Ansoff, 1977; Duncan, 1972; Huber et al., 1975; Terreberry, 1968). The phenomena have a high strategic importance; the sum total effect of the phenomena on the organization is unpredictable; and the organization has a short time in which to respond. The response is difficult to execute because external turbulence created by the phenomena leads to an inability to understand technological and market related developments in the external environment (Bstieler, 2005). The shifting foundation of understanding, if left unchecked, requires continuous and expensive project adaptation (Buganza et al., 2009).

External turbulence is difficult to characterize as shown by Buganza et al. (2009) in their compilation of the many adjectives used in the description of external turbulence:

| | |
|---|---|
| Hostile | (Covin & Slevin, 1989; Pradip N; Khandwalla, 1977; D. Miller, 1987) |
| Uncertain | (Pradip N; Khandwalla, 1977) |
| Complex | (Duncan, 1972; Emery & Trist, 1965) |
| Dynamic | (Atuahene-Gima, 1995; Dess & Beard, 1984; Duncan, 1972; Emery & Trist, 1965) |
| Volatile | (Bourgeois III & Eisenhardt, 1988) |

**Two perspectives at odds**

The literature has shown two perspectives on external turbulence that are at odds (Dess & Beard, 1984; Li & Atuahene-Gima, 2001; Tidd & Bodley, 2002). One perspective shows external turbulence leads to generally positive outcomes and the other perspective leads to undesirable outcomes.

***Positive outcome.*** Some researchers suggest that external turbulence causes firms to strive for growth by seeking new opportunities (Brown & Eisenhardt, 1995; Calantone et al., 2003; Calantone et al., 1997; Grant, 1996; Jimenez-Jimenez et al., 2008; Miles, Snow, Meyer, & Coleman Jr., 1978). The new product development processes in the fuzzy front end are used to survive the Schumpeterian world where firms must cope with high velocity change by finding new opportunities. In highly turbulent environments, firms gather information about the changes in the external environment and the new information has been found to actually improve the firm's innovativeness, risk taking and the speed of new product development processes (Calantone et al., 2003; Su, Xie, & Peng, 2010; Tidd & Bodley, 2002). Thus, firms may be more active in a turbulent environment because of the opportunities available.

***Undesirable outcome.*** In contrast, other researchers argue that external turbulence presents a high risk for firms because it is difficult to develop accurate plans for new product development activities (Antoniou et al., 2007; Iansiti, 1995; Song et al., 2001). External turbulence generates an overload of changes and a wave of new information that invalidates existing product plans, upsets control mechanisms and can freeze new product development activities (Antoniou et al., 2007; Atuahene-Gima, 1995; Bourgeois III &

Eisenhardt, 1988; Calantone et al., 2010; Covin & Slevin, 1989; Iansiti, 1995; D. Miller & Friesen, 1982; Song et al., 2001).

New product development processes in the fuzzy front end become a casualty of external turbulence as a result of the difficulty in processing information (Aldrich, 1979; Bstieler, 2005; Cummings et al., 1983; Terreberry, 1968). External turbulence leads to volatility and hard-to-predict discontinuities in an organization's external environment. Those changes create difficult or hard-to-forecast change. The difficulty in processing the information associated with that change increases uncertainty and ambiguity. New product performance is affected. The more specialized the organization, the more it was affected by external turbulence (Dess & Beard, 1984).

***Question to ask.*** Although both perspectives are insightful to explain the impact of external turbulence, this research proposes that the question to ask is not which perspective is correct, but how do the new product development teams overcome the challenges of information processing in either perspective.

The challenges associated with gathering and processing information is different in stable versus turbulent environments. In stable (non-turbulent) external environments, information gathering needed for new product development activity is a repetitive "learning-by-doing" exercise and searching for knowledge outside the firm only occurs when the firm lacks the knowledge internally it needs (Akgün et al., 2006; Johanson & Johanson, 2006). Firms entering turbulent markets using their normal routine of activities generally learn little about the turbulence driven changes and only make discoveries that relate to their status quo (Michael & Palandjian, 2004). However, in turbulent environments, the organizational memory of past new product development success and its dispersion through the organization can impede new product performance (Moorman & Miner, 1997). Organizational memory has a negative impact when experiencing high levels of market turbulence. The organizational memory of past success loses its favorable influence to lead the product to success as compared to environments with lower levels of market turbulence (Moorman & Miner, 1997).

External turbulence can invalidate the firm's repository of knowledge of existing markets (Akgün, Keskin, & Byrne, 2012). The assessment capability of the information processes to rebuild the knowledge repository is a crucial competence in overcoming the effects of external turbulence. Organizations that have the processes for seeking information to resolve uncertainty can make discoveries that counteract the effects of external turbulence.

**External turbulence in the literature.**

The next few sections examine how external turbulence is addressed in the new product development literature with a concentration on information processing. Topics include strategic orientation, resourced based view, strategic planning, senior management support, leadership of new product development teams and streams of research.

While it was the effects of external turbulence that first created interest in new product development processes, the literature gave more attention to variables controllable by the firm versus situational variables like external turbulence (Cooper & Kleinschmidt, 1987). Internal controllable variables were considered much more important to the success of new product development. The thinking was that even when the external factors such as turbulence are positive, they do not sweep the new product through the market to success (Cooper & Kleinschmidt, 1993; McNally, Cavusgil, & Calantone, 2010). It is the internal factors such as product design that will have more of an impact than whether the external market is calm or showing the discontinuities of external turbulence.

**External turbulence and strategic orientation**

The literature on strategic orientation is generally based on stable markets. Should external turbulence appear unexpectedly, many of the stable market conclusions in the literature are invalidated. However, there are still insights to be gathered.

***Strategic orientation definition.*** Strategic orientation determines whether a firm should orient around market, technology or entrepreneurship as the key factor guiding successful product decisions (Atuahene-Gima & Ko, 2001; Cooper & Kleinschmidt, 1987).

A market orientation became the default orientation in the literature (Brown & Eisenhardt, 1995). The mechanism employed by a market orientation enables the firm to learn about and to anticipate their customer's latent needs. In applying a market orientation, there are multiple facets on which to focus—customer, competitors, channels, others (Calantone et al., 2010).

A technology orientation is considered the opposite of a market orientation (Brown & Eisenhardt, 1995; Deshpandé, Grinstein, Kim, & Ofek, 2013; Gatignon & Xuereb, 1997). Using a technology orientation, firms have an R&D focus and emphasize acquiring and incorporating new technologies in new product development.

An entrepreneurship orientation is a hybrid of the market and technology orientations. It combines the market orientation's emphasis on market knowledge in defining products and the technical orientation's concentration on new technical knowledge that leaps past the competition (Atuahene-Gima & Ko, 2001; Covin & Slevin, 1989; D. Miller, 1983). It is entrepreneurship at its core because it involves greater risk taking and experimentation than the other orientations.

***Complexity in application.*** While a market orientation was shown to be significantly and positively related to product quality, innovation, and customer value in stable markets, the relationship is complex (Paladino, 2008). A pure market orientation often underperforms because it leads to interesting products that are attractive to the current customer group but does not necessarily lead to the introduction of novel products that expand its customer group (Ngo & O'Cass, 2012).

The particular focus on which to orient is contingent upon the challenge in the market. When demand is uncertain or declining then a concentration on the customer versus competitors and channels is recommended (Carbonell et al., 2009; Gatignon & Xuereb, 1997). When demand is stable or growing then attention to competitors is recommended (Gatignon & Xuereb, 1997).

Where technology plays a crucial role in new product success, a technology orientation is recommended because of its focus on product superiority (Brown & Eisenhardt, 1995; Cooper & Kleinschmidt, 1987). For service based products, a technology orientation is more predictive of success irrespective of the level of external turbulence (Spanjol, Mühlmeier, & Tomczak, 2012).

***In the presence of external turbulence.*** Turbulent markets have a different set of strategic orientation guidelines that are intended to adapt to the market trajectory, threats and stability conditions.

A greater quantity of information is needed. Applying a strategic orientation in turbulent environments requires interacting and gathering information from additional external constituents beyond just customers (Ottesen & Gronhaug, 2004). Those additional interactions include suppliers, regulatory bodies, industry groups, consultants and integrators.

The default market orientation does not necessarily have a positive effect on new product development success in the presence of external turbulence (Paladino, 2008). Attention is given to the challenge in the external environment versus the default market focus. When there is a high intensity of market competition and industry hostility, meaning competitive turbulence, a market orientation makes a greater contribution to new product development success than the other orientations Atuahene-Gima (1995). When technology is rapidly changing, meaning technological turbulence, a technology orientation is generally superior (Verganti & Buganza, 2005).

The manner in which the team processes information in crucial. Instead of declaring a strategic orientation, it is more important to maintain a state of creative tension in information gathering between those responsible for the technology development of new products and the organization's need to satisfy customer demands (McDonough & Leifer, 1986). When the balance swings too far in the direction of technology, technological wizardry runs amok. When it swings too far in the direction of customer demands, innovativeness can be stifled, and technology stagnation can result.

A firm's strategic orientation also shapes the way organizational members process information and react to the environment (Atuahene-Gima & Ko, 2001). Teams are influenced by their organizational perspectives they bring. Teams with a stronger technology orientation are more likely to prefer an explorative or radical innovation path and less likely to be influenced by the incremental requirements of the market (Saemundsson & Candi, 2013). An entrepreneurship orientation may lead to greater risk taking and, in uncertain markets, higher new product performance (Atuahene-Gima & Ko, 2001).

***Summary of information processing challenges identified.*** In employing a strategic orientation, information gathering changes in the presence of external turbulence and its presence may undermine the worth of some knowledge categories that lead to success in stable environments. To counteract, firms must gather information from a broader group of constituent sources and those knowledge gathering activities must be concentrated on learning about the causes and consequences of the external turbulence. Also, care must be taken in the information processing environment to ensure a balance of perspectives is maintained.

In stable markets, an organization can benefit from a strategic orientation, but, in the presence of external turbulence, a broad information gathering approach matters more. This outcome is different than was recommended when strategic orientation first entered the literature and a market orientation was considered the cornerstone of a successful new product strategy under any market conditions.

**External turbulence and the resource based view**

The literature has recognized the resource based view as a fundamental path to competitive advantage (Barney, 1991; El Shafeey & Trott, 2014; Ulrich & Barney, 1984), however when applied to new product development outcomes, it shows the challenges of addressing external turbulence and the importance of information processing in doing so.

***Resource based view definition.*** The resource based view makes the connection between the effectiveness of an organization's new product development processes and the competitive advantage it creates (Calantone et al., 2010; Gupta & Wilemon, 1990; Kleinschmidt, de Brentani, & Salomo, 2007; Verona, 1999) At its core, the resource based view maintains that resources are rare, non-imitable, and non-substitutable and the capabilities they generate are sources of competitive advantage (Barney, 1991).

When applied to new product development, the rare, non-imitable, and non-substitutable resources are the collection of novel processes and the process participants (project team members, project leaders, customers, suppliers and others) that take advantage of firm capabilities to drive superior new product results and provide the corresponding sustained competitive advantage (Barney, 1991; Gatignon & Xuereb, 1997; Kleinschmidt et al., 2007; Mahoney & Pandian, 1992).

***Contradiction in the presence of turbulence.*** The contradiction in the resource based view is whether resources that are rare, non-imitable, and non-substitutable are sufficiently fungible to address external turbulence. As previously stated, creating sustainable competitive advantage through resources that are rare, non-imitable, and non-substitutable is fundamental to long term product success. Turbulence, by definition, often upsets the experienced-based and differentiating processes that have been created.

Consequently, slack resources in one area that are rare, non-imitable, and non-substitutable must substitute for required resources in the area that must address the external turbulence (Evanschitzky, Eisend, Calantone, & Jiang, 2012; Kleinschmidt et al., 2007). Those resources need to transform into a different set of resources that are rare, non-imitable, and non-substitutable

Consider a firm successfully innovating in a stable market with extensive capabilities and slack resources in marketing when a firm in an adjacent market introduces a new technology that is now preferred in the firm's market. That firm must address the technological turbulence created by the competitive action and convert those slack marketing resources to engineering resources in order to address the new disruptive technology.

To address this contradiction, the resource based view has introduced the concept of dynamic resources. Dynamic resources are the organizational and strategic routines used by firms to achieve new resource configurations as markets emerge collide, split, evolve and die (Eisenhardt & Martin, 2000; El Shafeey & Trott, 2014; Teece, Pisano, & Shuen, 1997). Not all resources are dynamic resources and it is the responsibility of the senior management to anticipate the reconfigurations that will be needed and appropriately deploy dynamic resources.

The dynamic reconfiguration of resources also leads to a redefinition of competitive advantage under the resource based view (Eisenhardt & Martin, 2000; El Shafeey & Trott, 2014; Teece et al., 1997). Instead of long term competitive advantage, the definition for turbulent markets has changed to a series of temporary advantages.

***Connection to information processing.*** The resource based view did not counteract the effects of external turbulence. While it is strong firm resources that lead to new product success and long term competitive advantage in the resource based view, it is the immutability of those resources that can lead to failure in the presence of external turbulence. If cross-functional resource transformation is difficult, then success with the resource based view is a matter of firms accurately predicting external turbulence and having the proper assets that can transform resource configurations when needed.

For managers tasked with the creation of dynamic capabilities, the literature prescribes a focus on information gathering and "best practice" product development processes in the fuzzy front end (Eisenhardt & Martin, 2000; Grant, 1996; Marsh & Stock, 2006). In other words, activities that are essentially identical for all firms in the market versus firms that possess rare, non-imitable, and non-substitutable resource configurations.

**External turbulence and strategic planning**

The literature on strategic planning is based on well-ordered and predicable markets. Should unplanned external turbulence appear, many of the stable market conclusions in the literature are invalidated. However, there are still insights to be gathered.

***Strategic planning defined.*** Strategic planning is the formal and explicit administrative process to determine specific long-range objectives, generate alternative strategies and implement a system to monitor results (Scott, 1982). Strategic planning is fundamental to the rational plan stream of research and is posited to help an organization speed up new product development processes by resolving organizational conflicts early and in a manner that provides a clear vision of goals (Brown & Eisenhardt, 1995). Strategic planning is also thought to be a process that accumulates knowledge from past new product development processes and directs that accumulated knowledge to teams initiating new product development projects (Moorman & Miner, 1998). Large firms benefit more from strategic planning than do smaller firms and especially if the firm has a high R&D intensity (Song, Im, Bij, & Song, 2011),

***In the presence of external turbulence.*** A formal strategic planning process may hinder rather than improve new product development performance due to the high velocity of new information generated by external turbulence (Glaser & Weiss, 1993). In the other direction, the increased capabilities and resources available in teams within larger organizations are often more advantageous to the strategic decision-making process in turbulent environments than in stable ones (Haleblian & Finkelstein, 1993).

To compensate for external turbulence, strategic planning processes have become more decentralized, less staff driven and more informal while the plans themselves have become shorter term, more goal focused and less specific with regard to actions and resource allocations (Grant, 2003). Strategic planning systems are now a mechanism for coordination and performance management. Having lost the capability to plan in turbulent environments, strategic planning systems have a limited impact on the quality of decision making and the resulting innovativeness of the firm.

***Effect on information processing.*** Strategic planning mechanisms have systematic biases that often prevent decision makers from noticing the turbulence induced changes in their environment (Glaser & Weiss, 1993). The planning process leads both to an underweighting of the time-sensitivity of marketplace information and to a bias in favor of long-established marketing decisions that may now result in inferior performance.

Strategic planning did not counteract the effects of external turbulence. In the presence of external turbulence, activities other than strategic planning provide a more viable path to new product development project success (Moorman & Miner, 1997) and, across a broad range of organizations, there is a significant negative relationship between strategic planning and the number of new product development projects (Song et al., 2011).

In stable markets an organization can benefit from a strategic planning but in the presence of external turbulence, the rote thinking of strategic planning may blind the organization from gathering the information needed to understand the external turbulence induced changes affecting their portfolio of products and services.

## External turbulence and senior management support

While senior management support was found to be an antecedent to success in stable environments, senior management often hinders new product success in the presence of external turbulence by micro-management, resistance to new ideas and constraining information about the changed markets.

***Senior management and new product development.*** Senior management involvement either by direct participation or by monitoring behaviors has been identified as a key antecedent to new product development success in many studies (Brown & Eisenhardt, 1995; De Brentani & Kleinschmidt, 2004; Gupta & Wilemon, 1990; Sethi, Smith, & Park, 2001; Zirger & Maidiquie, 1990). New product development success in the fuzzy front end requires senior management to provide the proper balance of mission, people, communication and empowerment. (Cooper, Edgett, & Kleinschmidt, 2004; Thwaites, 1992). In some tasks such as entering new non-domestic markets, senior management support was shown to be more important than the market condition (De Brentani & Kleinschmidt, 2004; Zirger & Maidiquie, 1990)_ENREF_158.

Successful new product development in the global environment is increasingly complex and risk-intense compared to the primarily heritage domestic markets of few decades ago (De Brentani & Kleinschmidt, 2004). Successful senior management must create a globalization culture within the organization that is backed up with sufficient resources. De Brentani and Kleinschmidt (2004) found the best performers had a positive, balanced approach to globalization culture, resources committed and senior management involvement while the worst performers had a hands-off approach.

***In the presence of external turbulence.*** Senior management can contribute to poor performance in the presence of external turbulence (Cooper et al., 2004; Haleblian & Finkelstein, 1993). The worst performing senior management teams tended to micro-manage versus relying on the new product development team for day-to-day operations and decisions (Cooper et al., 2004). The more conservative the senior management style, the greater it is effected by external turbulence (Pradip N. Khandwalla, 1973).

***Senior management can counteract external turbulence.*** Senior management can counteract external turbulence by a commitment to learning in a way that encourages and supports the product development team in working to counteract the effects of external turbulence (Ellinger & Cseh, 2007). Firms should use a more bottom-up approach in their processes that is less influenced by senior management (Carson et al., 2012). It is the bottom up market vision versus the top down view that is most associated with success in the presence of external turbulence (Reid & de Brentani, 2012).

***Senior management resists new information.*** Senior managers often resist the newness of approaches that are needed to counteract external turbulence because it tends to threaten the status quo and their power base (Sethi, Iqbal, & Sethi, 2012). Dominant senior managers tend to restrict the flow of information down the chain in turbulent environments and their motivation is often to preserve the status quo (Eisenhardt & Bourgeois III, 1988). Since counteracting external turbulence may require substantially more information than needed in stable environments, the information restriction by senior management can lead to poor new product performance (Haleblian & Finkelstein, 1993).

**External turbulence and streams of research**

In the decade after new product development processes became a significant topic in the literature, Brown and Eisenhardt (1995) published their seminal work on new product development and organized the literature into three common streams of research—new product development as a communication web, new product development as a rational plan and new product development as disciplined problem solving. Evaluating these streams in the context of this research shows the literature's viewpoint on addressing external turbulence.

***Rational plan.*** The rational plan perspective emphasizes how a successful product development outcome is the result of rational planning and execution (Brown &

Eisenhardt, 1995). It is the embodiment of a market orientation executed using a sequential new product development model.

In this perspective, inward looking factors such as product design, product concept, and predevelopment planning are more important to commercial success than external factors such as external turbulence (Brown & Eisenhardt, 1995; Cooper & Kleinschmidt, 1987; Zirger & Maidiquie, 1990). A product succeeds because it has design advantages over the competition, is targeted at an attractive market and is delivered by a new product development process that is competently executed by a proficient cross functional team. The implicit recommendation for external turbulence is avoidance. Product success comes from entering large and growing markets with low competitive intensity (Brown & Eisenhardt, 1995; Cooper & Kleinschmidt, 1993; Zirger & Maidiquie, 1990).

While that prescription may be the "happy path" to new product success, it does not represent the global market faced by many firms. External turbulence, by definition, is not predictable and calm markets today may be turbulent tomorrow. Firms cannot be expected to abandon a market when it becomes turbulent, so firms need to be able to address external turbulence as part of their standard product development process.

***Communication paths.*** Brown and Eisenhardt (1995) identified information processing as antecedent to successful new product outcomes. The authors defined two communication paths used in developing products. One path is the information-processing view that emphasizes frequent and appropriately structured task communication. The second communication path has a resource dependence view and emphasizes that frequent political communication (typically external to the team) leads to higher performing development processes by increasing the resources such as budget, personnel and equipment available to the team.

The first communication path, the information-processing view, codified the existing literature on information processing in new product development processes and is more relevant to this research. It included the introduction of the cross functional team and all manner of boundary spanning communication both internal and external (Ancona & Caldwell, 1992; Brown & Eisenhardt, 1995).

The boundary spanning activities include external communications, scouting for new information about the new product development project and addressing uncertainty (Ancona & Caldwell, 1992). Communication paths has two limitations. The research makes little distinction between communication that is external to the team and communication that is external to the organization. In assessing communication paths, most of the analysis centers on function-to-function communication within the cross-functional team. Second, the research does not address any difference in information processing requirements between stable and turbulent external conditions. This research will be looking whether more communication is needed with constituents outside the cross functional team to counteract external turbulence

***Disciplined problem solving.*** Disciplined problem solving identifies an autonomous product need and applies disciplined problem solving to fill the need (Brown & Eisenhardt, 1995). This stream emphasizes the heavy weight product manager. The new product development project is executed by the heavyweight product manager's cross functional team. The emphasis on a high level of communication among constituents and a flexible organization of work according to the demands of the task.

In this thread, Brown and Eisenhardt (1995) addressed some of the product development practices that this research will evaluate for their ability to help counteract external turbulence. In the Brown and Eisenhardt (1995) review, these practices were only addressed by their applicability to stable markets. Their review included more experiential product design through frequent iterations which the authors found to be successful and compression tactics which the authors found were not successful.

***External turbulence as an item for future research.*** A common thread across the streams of research is the lack of consideration for external turbulence. In assimilating the existing research into the three streams, new product development processes were only studied in stable market conditions. No consideration was given to external turbulence, the velocity of markets and similar factors. The authors' only comment on external turbulence was in the agenda of possible future research.

**Sources of external turbulence for this research**

This first section of this literature review shows the existing literature has a bias towards researching stable markets in presenting how product development functions. In contrast, this research concentrates on addressing the challenges of counteracting external turbulence. The continuing economic globalization means external turbulence is arriving with greater frequency and originating from multiple sources.

For this research, there are four sources of external turbulence to be examined and included in the research model on page 79. Many taxonomies to describe external turbulence have been proposed (Buganza et al., 2009; Emery & Trist, 1965) and three of the four sources of external turbulence in this research will come from the popular

Jaworski and Kohli (1993) taxonomy (technological, market, competitive). The fourth source is regulatory turbulence. Because healthcare is the targeted industry for this research, the examination of regulatory turbulence is appropriate.

***Technological turbulence.*** Technological turbulence is the rate of technological change (Calantone et al., 2003; Jaworski & Kohli, 1993).

In defining technological turbulence, the technology within that industry is in a state of flux that is often caused by a technological discontinuity (Lakemond et al., 2013). The departure from existing technology and practices created by the discontinuity increases uncertainty for the new product development team (Calantone et al., 2010; Danneels & Kleinschmidt, 2001; McDermott & O'Connor, 2002).

Based on data from Asian countries, technological turbulence is overall more positively related to innovative outcomes versus market turbulence (Calantone et al., 2010).

In the other direction, technological turbulence has a negative impact on costs from addressing the uncertainty but has no direct effect on quality or cycle time (Ragatz et al., 2002). Technological turbulence affects new product development efficiency that leads to ineffective prototypes, a higher level of design changes and potentially chaos on the product development team (Song & Montoya-Weiss, 2001; Souder et al., 1998).

***Market turbulence.*** Market turbulence is the rate of change in customer preferences (Jaworski & Kohli, 1993). This change refers to ambiguity about the type and extent of customer needs and requirements for the new product (Moriarty & Kosnik, 1989).

***Competitive turbulence.*** Competitive turbulence considers the ability of competitors to thwart a firm's market actions (Jaworski & Kohli, 1993). Competitive turbulence behaves as a pure moderator (Saemundsson & Candi, 2013; S. Sharma, Durand, & Gur-Arie, 1981) and shows as shorter product life cycles, rising development costs, and greater competitive intensity (Drechsler, Natter, & Leeflang, 2013).

***Regulatory turbulence.*** Regulatory turbulence is high regulatory fluctuation and stringency (Wijen & Van Tulder, 2011).

Regulation changes the basis of competition by setting barriers to entry and forcing regulated firms to follow certain rules that, correspondingly, change the behavior of the market participants (Huesig, Timar, & Doblinger, 2014). The existence or expectation of regulation reduces the probability that an organization will make research expenditures and intuitively will reduce the new products that result (Goel, 2007).

Since the regulatory authority has an oversight on market activities, it leads to differences in markets at the country level and also at supranational levels such as the European Union (EU) versus the corresponding market outcome in unregulated markets (Fernández & Usero, 2009; Huesig et al., 2014).

Even when regulatory actions are disproportionate and discriminatory, the outcome may not favor the market participants intended. A study in China showed that in turbulent environments the tradition of "guanzi" (the exchange of favors), where local political leaders are treated lavishly to circumvent undue regulatory scrutiny, was found to negatively impact project financial outcome (Li & Atuahene-Gima, 2001).

In addressing regulatory turbulence, firms consider the level of regulatory uncertainty perceived and the firm's exposure to future regulations (Engau & Hoffmann, 2011). Higher levels of regulatory uncertainty lead to the application of a broader range of strategies and the greater likelihood of future regulation leads to more active coping activities. All taking away focus from the success of the product development process unfolding.

## New Product Development Practices

The literature review moves from external turbulence to the second of four sections, new product development practices. New product development practices are the activities performed in the fuzzy front end and provide the foundation for new product development success (Cooper, 1997; Khurana & Rosenthal, 1998; Thwaites, 1992; Zhang & Doll, 2001). This section of the literature review shows how the existing literature on new product development practices addresses external turbulence.

### New product development practices defined

New product development practices are the disciplined and defined set of tasks, steps and phases that describe the normal means by which a company repetitively converts embryonic ideas into salable products and services (Kahn, 2004; J. Kim & Wilemon, 2002). New product development processes in the fuzzy front end are unlike other business processes because they span across the organization and also bridge to constituencies outside the organization (Thwaites, 1992). Successful new product development processes require the proper balance of mission, people and communication (Thwaites, 1992). They require execution by a competent, well trained and committed cross functional staff along with the supporting infrastructure that enhances information gathering. The quality of the new product development process when measured by concurrency, formality and adaptability is positively associated with the achievement of new product release goals such as quality, unit cost and time-to-market (Tatikonda & Montoya-Weiss, 2001).

The literature review for internal new product development practices presents two types: traditional models and flexible practices. Traditional models are the sequential models of new product development previously described. Flexible practices are more recent proposals and are intended to address the challenges of external turbulence. This portion of the literature review provides the foundation to examine whether flexible internal product development practices solve the challenges with traditional sequential practices when they are in the presence of external turbulence.

**Traditional models of new product development**

Many traditional models of new product development processes are based on an assumption formulated in the late 1980's that superior results come from a structured and formal design process where fuzzy front end activities are organized into sequential process steps (Buganza et al., 2009; Cooper, 1990; Griffin, 1997; Lynn, Skov, & Abel, 1999; Menke, 1997). In each step, a cross functional team considers alternatives and eventually settles a certain aspect of the new product proposal. At the end of each step, management makes a "continue or kill" decision and provides direction for the project's next step.

Sequential new product development processes are characterized by a structure that minimizes changes to the new product plan once each step is completed (Cooper, 1990). At the end of the fuzzy front end steps, the initiative has evolved from a fuzzy concept to a firmly defined initiative ready to begin construction. Sequential fuzzy front end process flows were reasoned to lead to an effective product definition that will save downstream resources in terms of cost, time, and engineering-hours (Calantone et al., 2003; Droge, Claycomb, & Germain, 2003).

While sequential new product development processes have been shown to be effective in stable environments (Cooper & Kleinschmidt, 1996), their value has been questioned in uncertain and dynamic environments (Bhattacharya et al., 1998; Bstieler, 2005; Buganza et al., 2009; Buganza et al., 2010; Buganza & Verganti, 2006; Cordero, 1991; Gold, 1987; Iansiti & MacCormack, 1997; Kessler & Chakrabarti, 1999; Mabert et al., 1992; MacCormack & Verganti, 2003; MacCormack et al., 2001; Millson et al., 1992; Song & Montoya-Weiss, 2001; Wind & Mahajan, 1997).

In explaining the effect of external turbulence on sequential new product development processes, the literature did not question the fundamental sequential structure of the new product development processes. In the alternative, it suggested the adverse effects of external turbulence on sequential new product development processes were an industry specific challenge (Bhattacharya et al., 1998; Eisenhardt & Bourgeois III, 1988; Eisenhardt & Tabrizi, 1995) versus a general challenge across all industries. Only high velocity markets such as software companies and internet ecommerce would be affected by external turbulence

The literature considered the process acceleration tactics intended to address external turbulence as a tradeoff from the superior sequential process model. While new product development process acceleration is most appropriate in turbulent environments, it will have a negative tradeoff on development costs, product quality and project success (Kessler & Chakrabarti, 1996). It requires making complex tradeoffs that must balance product attractiveness, the firm's risk aversion and potential benefit of using more time and information (Bhattacharya et al., 1998). The trade-off also has a contingency component where new product development processes should adapt to different environmental conditions and to varying degrees of uncertainty (Bstieler, 2005).

In the second half of the 1990s, the research questioned whether industry was the right criterion on which to address the effects of external turbulence on new product development processes (Buganza et al., 2009). The research continued to evolve and determined the impact of external turbulence was a cross industry challenge because technology and markets are shifting rapidly across the globe, (Bhattacharya et al., 1998; Buganza et al., 2009; Iansiti, 1995; Iansiti & MacCormack, 1997; Massini et al., 2002; Verganti, 1999). The prescription was the addition of flexibility in new product development processes to cope with these shifts.

**Flexible practices in new product development**

Flexible practices in new product development were proposed to reduce the odds that markets have changed between the time each aspect of the product or service design is frozen and the eventual launch (Cordero, 1991; Wind & Mahajan, 1997). The addition of flexibility was intended to minimize major redesigns, increase the capability to react to unexpected changes and diminish the likelihood of the newly released product or service becoming obsolete soon after launch and thus causing a need for a new round of product development (Buganza & Verganti, 2006). Flexible practices are characterized by their ability to generate and respond to new information for a longer proportion of the new product development lifecycle (MacCormack et al., 2001).

The approaches recommended can be grouped into the three categories shown (Bstieler, 2005; Buganza et al., 2009; Cooper & Kleinschmidt, 1994; Cordero, 1991; Gold, 1987; Mabert et al., 1992; Millson et al., 1992).

| | |
|---|---|
| Process execution. | Simplify tasks, reduce delays, eliminate steps, update management approaches, ensure accountability and define specific project goals |
| Process speed. | Use overlapping and parallel steps |
| Integrative practices. | Access new external and internal sources of knowledge |

The next sections of this literature review will examine each approach.

**Process execution in new product development**

Process execution is the foundation for new product development success. Correspondingly, the activities of the new product development team are a major determinant in overcoming the effects of external turbulence (Bstieler, 2005; Cooper & Kleinschmidt, 1994; Kessler & Chakrabarti, 1999). While a proficient execution of new product development activities are important, it is not of interest in this research. Ensuring effective process execution is the normal and customary activities performed by all management teams, across all activities and in all market conditions, stable and turbulent.

This research is interested in external turbulence and explores the flexible practices that counteract external turbulence. Therefore, this research will concentrate on the remaining two types of flexible practices: process speed and integrative practices. They are of interest because of their relevance to addressing external turbulence. They have replaced or augmented the traditional sequential practices to counteract the effects of turbulence.

Process speed and integrative practices have further relevance to the information processing environment. It is hypothesized that uncertainty and equivocality may require different actions to counter. Uncertainty should be addressed by speeding up processes while equivocality should be addressed by steps that often slow down the processes such as integrative practices (Carson et al., 2012).

The balance of this literature review section will explore process speed and integrative practices.

**Process speed in new product development**

Process speed refers to the pace of activities in the fuzzy front end. In new product development, speed is always a consideration and there is no single way to be fast (Cordero, 1991; Eisenhardt & Tabrizi, 1995; Kessler & Chakrabarti, 1996).

***Process speed described.*** The early research from the nineties, looked at process speed as a trade-off with process execution quality rather than as a stand-alone desirable attribute (Bhattacharya et al., 1998). The tradeoff was, "Do you want it fast or do you want it right?"

The application of process speed was thought to only be possible when firms had a high proficiency in the technology or the market (Bstieler, 2005). Since that proficiency only exists in stable markets, speed was not deemed desirable in the presence of external turbulence. The higher the external turbulence then the slower the new product project should progress.

The trade-off point of view presented in the nineties has since changed. Process speed has been associated with both heightened quality and lower costs (Stanko, Molina-Castillo, & Munuera-Aleman, 2012). A quick translation of market opportunities into product concepts decreases the risk of a late market introduction of a newly-developed offering (Calantone et al., 2003). In turbulent markets, information can become stale quickly and there is uncertainty about the future value of any piece of information (Glaser & Weiss, 1993).

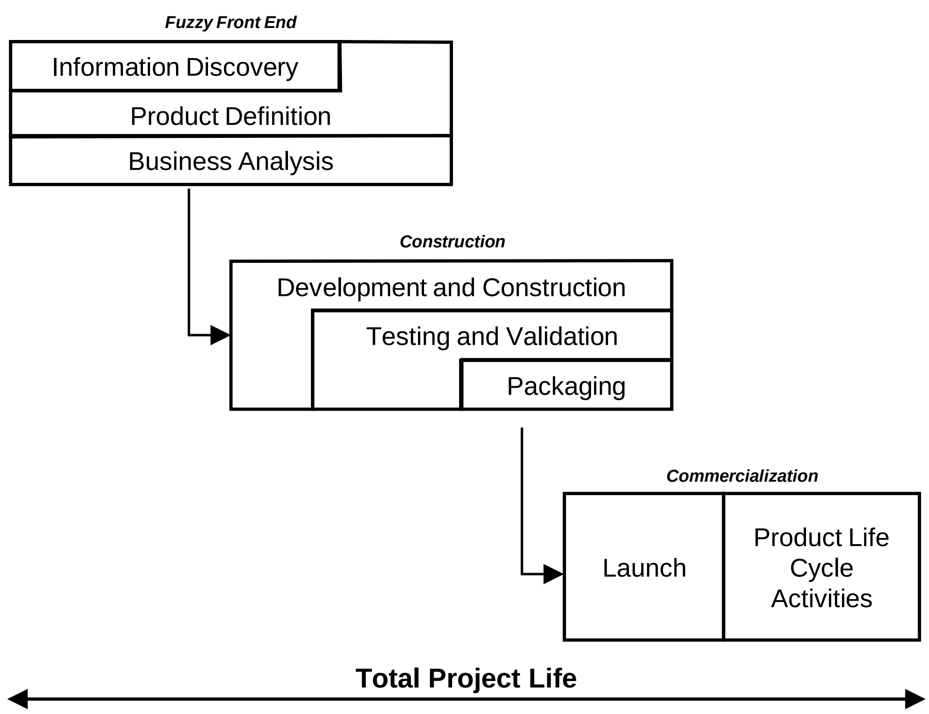
In turbulent or hard-to-forecast markets, firms need to speed up product development (Bstieler, 2005; Buganza et al., 2009; Eisenhardt & Tabrizi, 1995; Millson et al., 1992); however, new product success and process speed are not connected by a linear relationship when in the presence of external turbulence (Chen, Reilly, & Lynn, 2012; Langerak & Jan Hultink, 2006). Process speed has an inverted U-shaped relationship with new product profitability. The reverse U-shaped relationship between speed and success results from the diseconomy of time-compression as uncertainty increases in the presence of external turbulence. High levels of uncertainty constrain the absorptive capacity of the new product development team in addressing new information. With low turbulence, new product development teams understand the technology used and the market resulting in a direct, linear benefit of speed. Correspondingly, profit maximization occurs at a higher development speed for simple incremental product improvements than for more complex line additions and replacements.

There are multiple approaches for gaining speed in new product development as described by the Eisenhardt and Tabrizi (1995) taxonomy that consisted of compression tactics and experiential tactics.

***Compression tactics.*** Compression tactics build on a rational engineering perspective and take advantage of time efficiency by compressing sequential steps (Bstieler, 2005; Eisenhardt & Tabrizi, 1995; Millson et al., 1992). Common tactics include concurrent engineering, overlapping steps and conditional go-aheads.

Figure 3 shows the traditional sequential new product development process from figure 2 (page 17) and applies compression tactics.

*Figure 3: New product development process showing compression tactics (Derived from Iansiti, 1997)*




For example, packaging begins concurrently while the development and construction phase is still ongoing; product definition and business analysis are overlapped versus occurring sequentially; and launch processes conditionally begin before the product has complete testing and validation. The results in the time from project start to product launch are quicker than with a traditional sequential new product development methodology.

***Experiential approach.*** The experiential approach accelerates learning about the turbulent environment through improvisation, real-time experience and flexibility (Buganza et al., 2009; Eisenhardt & Tabrizi, 1995; MacCormack et al., 2001). The additional knowledge is used to reduce uncertainty in executing the new product development process. Tactics include rapid project iterations, extensive testing, customer experiments, frequent project milestones and a delayed concept freeze.

***Process speed tactics in this research.*** To represent process speed in this research, three tactics were chosen and included in the research model on page 79: agile methodology, early feedback and late decision making.

***Agile methodology.*** Agile methodology is characterized by rapid development iterations to gain feedback combined with overlapping processes where the next iteration begins before the current iteration finishes (Mohan et al., 2010; Zhang & Doll, 2001).

Agile development is in contrast to the traditional waterfall development methodology that focuses on preparing a complete and detailed design specification before the execution - construction phase begins (Guntamukkala et al., 2006). The parallelism of an agile methodology has been identified as one of the better methods for increasing the speed of the new product development process in turbulent environments (Bstieler, 2005; Kessler & Chakrabarti, 1999; Meso & Jain, 2006; Millson et al., 1992). Along with parallelism, an agile methodology succeeds with distributed decision making and a decentralized control mechanism versus a rigid and static approach. The interactions occur through peer to peer social interaction across the teams, groups and entities involved (Cao, Mohan, Xu, & Ramesh, 2009; Meso & Jain, 2006).

***Early feedback.*** Early feedback refers to regularly gathering feedback from multiple constituents at the earliest stages of the product development process (Buganza et al., 2009; Lakemond et al., 2013; Narasimhan et al., 2006).

Gathering, sharing and exploiting knowledge with multiple constituencies has its greatest impact in the early stages of the new product development process (Mothe & Thi, 2010). A common mechanism is through regular prototypes shown to users to gather their feedback (Buganza et al., 2009; MacCormack et al., 2001).

Some research has shown that product changes made based on feedback from the early prototypes increases the quality of the end product released (Buganza et al., 2010; MacCormack et al., 2001). Early feedback is hypothesized to work by counteracting technology and market uncertainties with continuous experimentation that regenerates knowledge dynamically.

***Late decision making.*** In late decision making, product concepts, capabilities and designs are not frozen until the last phases of the development process (Buganza et al., 2009; Buganza et al., 2010). Late decision making emphasizes the ability to generate and respond to new information for as long as possible during the new product development process (Bhattacharya et al., 1998; Buganza et al., 2009; MacCormack et al., 2001)_ENREF_21. It involves continually assessing market information and customer input that was not available at the beginning of the process. Decisions are made by an offset of the value of the new information against the difficulty in making changes to the product definition.

As previously mentioned, in a traditional new product development process, a sharp product definition that is made early in the fuzzy front end is considered a crucial antecedent to new product success (Bhattacharya et al., 1998). The construction phases then begin with certainty that the specifications will not change.

In turbulent environments, an unchanging product specifications is considered, at best, an elusive goal (Bacon, Beckman, Mowery, & Wilson, 1994; Krishnan & Ulrich, 2001). Forcing design decisions too early may generate a specification that is unattractive to the target customer group when the product is launched (Bourgeois III & Eisenhardt, 1988; Iansiti, 1995; Wind & Mahajan, 1997).

**Integrative practices in new product development**

New product development success requires integrative practices to solve problems (Brown & Eisenhardt, 1995; Clark & Fujimoto, 1991; Eisenhardt & Martin, 2000; Marsh & Stock, 2006; Schweitzer, Gassmann, & Gaubinger, 2011; Wheelwright & Clark, 1994; Zander & Kogut, 1995). Integrative practices are the processes used by the organization to regenerate its knowledge base (Eisenhardt & Martin, 2000; Kogut & Zander, 1992; Marsh & Stock, 2006). The organization does so by exploiting information sources both internal and external to the organization (Edmondson & Nembhard, 2009; Eisenhardt & Martin, 2000). Applying the theory of organizational information processing from Daft and Lengel (1986), the more uncertainty and equivocality, the greater the use of integrative product development practices.

Integrative practices are more beneficial in turbulent environments than in stable environments and especially when time to market is crucial (Cheng & Huizingh, 2012;

Hong, Doll, Nahm, & Li, 2004; Schweitzer et al., 2011). Organizations that face high levels of external turbulence have to ask a large number of question to acquire more information and to learn answers (Daft & Lengel, 1986; Daft & Macintosh, 1981). Beyond just the quantity of relevant information gathered, the information needs to be fresh because there is uncertainty about the future value of any piece of information in turbulent environments (Glaser & Weiss, 1993).

Integrative practices are not a standalone activity. To be effective, organizations require an orderly internal knowledge integration capability as an antecedent to effective external knowledge integration (Buganza & Verganti, 2006; Koufteros et al., 2002; Verganti & Buganza, 2005). To be successful at knowledge integration from external parties, firms must be competent at managing internal knowledge processes and have a strong organization of the new product development team, but have a low formalization in how new products are conceived.

Integrative practices can also have negative outcomes that include leaks of intellectual property and the dependence upon external sources (Schweitzer et al., 2011). The inclusion of external constituencies in the fuzzy front end leads to a fundamental trade-off between knowledge adaption and utilizing the full value of the external knowledge (Almirall & Casadesus-Masanell, 2010; West, 2003). By including outsiders, suppliers and foundational customers, the firm may make knowledge discoveries that would be unlikely without the outside expertise, however the property rights of the external constituencies may limit the firm's ability to capture full value. The collaboration with external constituencies leads to coordination costs of working together and opportunity costs of not including incompatible external sources (Schweitzer et al., 2011).

There is also a tendency for new product teams to create a greater variety of products in the current market to ensure the chance that a customer will find something of interest but at the cost of expansion into other markets (Al-Zu'bi & Tsinopoulos, 2012).

***Foundational customers.*** Foundational customers are customer representatives who participate in the new product development process and in a manner that helps shape the requirements (Carbonell et al., 2009; Gatignon & Xuereb, 1997).

Foundational customers have been found to increase flexibility through regenerating knowledge in multiple studies (Buganza et al., 2010).

In the presence of market turbulence, customers are better sources of external knowledge than suppliers (Schweitzer et al., 2011). In a study, Ottesen and Gronhaug (2004) found successful customer interactions in highly turbulent environments were not about wants and needs but other relationship issues such as supply chain concerns, the regulatory environment, competitors and new technology. Correspondingly, the same study found that 55% of the interactions about customers' wants and needs were made with other actors such as suppliers, distributors, integrators and others (Ottesen & Gronhaug, 2004).

Customer interaction may help shorten development cycle time and especially with service innovations (Alam, 2006). Having foundational customers that can disclose significant know-how reduces project risk (McDermott & O'Connor, 2002).

New product initiatives rely on foundational customers to communicate product value and firm commitment to others (Wang, Song, & Zhao, 2014).

***Supplier participation.*** Supplier participation refers to the roles that suppliers play in the product development process. It ranges from simply delivering parts based on a specification to substantial involvement in the design process (Cusumano & Takeishi, 1991; Gatignon & Xuereb, 1997; Ragatz et al., 2002). Utilizing suppliers to participate in critical development activities is a tactic to lower risk (McDermott & O'Connor, 2002).

Kotabe and Scott (1995) found that firm size was significant with small firms being more innovative in cooperative relationships with suppliers than mid-size or larger firms. Also, they found over time; the effectiveness of the cooperative relationship diminished, possibly from the patterns of interaction becoming rigid rather than adapting to changes in environment: market, technology and others.

Droge et al. (2003) found that using knowledge from supply chain members, whether suppliers or customers, leads to significant financial performance outcomes. The collaborative arrangements with suppliers and customers enable better use of knowledge resources. In addition, as complexity and breadth of knowledge sharing increase, the ability of competitors to imitate is lessened.

The sharing of knowledge with external suppliers about the interaction with the customer has a positive effect on quality and on the adaption of the suppliers products into the solution (Buganza & Verganti, 2006).

Ragatz et al. (2002) found that integration of suppliers into the new product development process leads to improvements in cost, quality, and cycle time and especially so in the presence of technological turbulence.

In the presence of technological turbulence, suppliers versus customers are better sources of external knowledge (Schweitzer et al., 2011). (Buganza & Verganti, 2006) found that sharing front-end technological competences with external suppliers has a positive effect on quality of adaption. In the other direction, suppliers in turbulence markets involved in integrative activities may act with opportunism for their own benefit that will over time erode trust of the supplier and commitment of the firm to the supplier (Mysen, Svensson, & Payan, 2011).

## **Information Processing Environment**

The literature review moves from new product development practices to the third of four sections, the information processing environment. The information processing environment is the portion of the new product development processes that handles the two opposing states of uncertainty and equivocality created by external turbulence.

### **Definition of the information processing environment**

The definition of the information processing environment is based on the environment construct in the theory of organizational information processing from (Daft & Lengel, 1986). In creating their theory, Daft and Lengel (1986) assimilated various threads in the literature about information processing into the theory of organizational information processing. Their theory has three assumptions that refine the definition of the information processing environment (Daft & Lengel, 1986). First, organizations have a limited capacity to gather and process information. Second, within the organization, information processing happens through multiple individuals and across multiple departments. Those individuals must converge on a similar interpretation of the information. Third, the activities within each group or department may be different but they must coordinate with their peers in processing information.

For this research, the information processing environment is a set of coordinated internal processes used in the fuzzy front end to gather and process information about the external environment. The information is used to address external turbulence and handle the two opposing states of uncertainty and equivocality that are created by external turbulence. The information processing environment is constrained by the limited time and resources available for the various constituents to gather information and converge on an interpretation of the external environment.

This section of the literature review shows how the existing literature on new product development practices addresses external turbulence and highlights a common thread of information processing challenges.

**Information processing and cross functional teams**

In the fuzzy front end, the information processing environment exists within the new product development cross functional team. Cross functional teams are the significant organizational work unit in new product development and their teamwork is considered a crucial antecedent to new product development success (Brown & Eisenhardt, 1995; Gupta & Wilemon, 1990). Key measures of process performance in new product development processes are often team related and include metrics around teamwork, team productivity, and engineering change time (Syamil et al., 2004).

Cross functional teams in new product development are unique compared to most organizational teams because of their temporary nature and their singular assignment to the new product development project at-hand (Olson, Walker Jr., & Ruekert, 1995; Zhang & Doll, 2001). They are generally composed of individual contributors from the product management, marketing and engineering groups within the organization and come together as a team to execute a new product development activity. Individual cross-functional new product development team participants singularly lack the required knowledge and skills needed from other relevant domains and establish relationships with like-minded colleagues to obtain those additional capabilities (Ulrich & Barney, 1984). Together, the cross functional team achieves the goals of the new product development activity.

To be successful, cross functional teams do not need physical proximity, task interdependence or autonomy (Sethi, 2000); however, to work together effectively, superordinate identity within the team is positively related to new product success (Sethi et al., 2001). Superordinate identity is the extent to which team members identify with the team rather than merely with their functional areas.

Alternatively, social cohesion has the opposite effect and is negatively related to new product success (Sethi et al., 2001). Social cohesion is the strength of interpersonal ties among individual team members. Considered together, the relationship between superordinate identity and new product success is strengthened as encouragement to take risk increases, but it is weakened as social cohesion moves beyond a moderate level.

***Cross functional teams.*** Cross functional teams process large amounts of information in the fuzzy front end to create the various product attributes such as target market segments, sales channels, price, features, technologies and other parameters (Bacon et al., 1994). It is through information processing that the cross functional team addresses external turbulence. They do so by processing information about their external environment to address the two opposing forces of uncertainty and equivocality (Daft & Lengel, 1986).

Cross functional teams do not necessarily counteract the effects of external turbulence (Orton & Weick, 1990). As previously stated, external turbulence can overwhelm the information processing environment with an overload of new information. The next few subsections will examine facets of cross functional teams including team structure, psychological factors, transactive memory systems, team learning, national culture, slack resources and team leadership.

***Cross functional team structure.*** The research is not in agreement on the optimal construction and process for cross-functional teams. Cross functional teams often have complex decentralized structures; use informal processes that are consensual and participative; and are motivated by the project outcomes (Orton & Weick, 1990). Other research has found a high formalization of the new product development team has a positive effect on both the frequency and rapidity of adaption of technologies (Buganza & Verganti, 2006).

The stage within the new product development process plays a role in cross functional team performance (Ancona & Caldwell, 1992). A cross-functional team structure that is successful in the fuzzy front end may require adjustment when the project moves into the construction phase.

Also, the methods that cross-functional teams use to achieve success can vary by the type of new product to be developed (Barczak & Wilemon, 1989). Other researchers have found limitations in inter-functional coordination, the bedrock upon which success in using cross functional teams is based (Gatignon & Xuereb, 1997). Although it is clear that new product development teams are often driven by R&D, the interface between marketing and R&D is still often problematic, leading to suboptimal inter-functional coordination.

The appropriate organizational structure to maximize new product development success depends on the situation both inside and outside the organization.

Droge, Calantone, and Harmancioglu (2008) found an organic organizational structure leads to innovativeness. Correspondingly, resource dependency theory suggests more participative structures are likely to improve the effectiveness and timeliness of the development process when the product being developed is truly new and innovative (Olson et al., 1995; Schellenberg & Miller, 1998).

In the opposite direction, Calantone et al. (2010) found a mechanistic organizational structure was positive in relation to new product outcomes across a broad range of product and service activities. Furthermore, the matrix form of a mechanistic organization structure has been found to be successful in new product development processes (Katz & Allend, 1985). In the matrix structure, high performance was associated with balanced levels of influence between project and functional managers. The highest performance occurred when project managers had greater levels of organizational influence and when functional managers had greater influence over technical project details.

Even a bureaucratic structure has its place and is likely to be more successful on less innovative projects (Olson et al., 1995; Schellenberg & Miller, 1998). However, bureaucratic structures are less effective for organizations operating in turbulent environments.

In counteracting external turbulence, organizational structure is dependent upon the situation. Formal and cross-functional product teams are crucial to incorporating customer input, but, in the case of technological turbulence, a flat organizational structure may improve new product performance through the ability to generate rapid product iterations (Buganza et al., 2009). In stable markets, the functional diversity of the team showed no effect on new product innovativeness (Sethi et al., 2001).

In gathering knowledge, weak inter-unit ties help the project teams search for useful knowledge in other subunits but impede the transfer of complex knowledge (Hansen, 1999). Complex knowledge tends to require a strong tie between the two teams for a transfer to be successful. In a study of 120 new-product development projects within 41 divisions of a large electronics company, weak inter-unit ties speed up the project development process when knowledge is not complex but slows the process down when knowledge is highly complex.

No one organizational structure is superior in counteracting external turbulence and the structure chosen is dependent upon the unique circumstances of that project.

### Information processing and team psychological factors

The information processing environment is affected by cross functional team psychological factors and those factors impact the firm's ability to address external turbulence (Reid & de Brentani, 2012). It is the firm's attitudes towards new information that is important in addressing external turbulence. In the presence of external turbulence, the ability of the team to create the market vision of the new product is a significant factor in the eventual success of the initiative.

The new product development team must remain open to novel interpretations, the recombination of knowledge and the questioning of held assumptions about markets, technology and other external factors (Spanjol et al., 2012). Inefficiencies in addressing new information come from the differing attitudes of functional areas within the organization (like R&D versus marketing) in assigning values to the usefulness of external information (Song et al., 2001). The differing interpretations are exacerbated by the presence of external turbulence.

Spanjol et al. (2012) used the tangential concepts of proactivity and open-mindedness which together show the will and foresight to maintain a forward-looking perspective in reacting to changes. A "competency trap" can cause firms to heavily rely on a few experiences to develop routines and, in doing so, discount later experiences thereby increasing the difficulty in learning from experience (Michael & Palandjian, 2004). New product development teams that are proficient across a broad range of capabilities are more likely to succeed in the presence of external turbulence than those teams that are not (Song & Montoya-Weiss, 2001).

**Information processing and transactive memory systems**

Dayan and Elbanna (2011) studied transactive memory systems combined with intuition to address information processing in the presence of external turbulence. Transactive memory systems combine the knowledge possessed by each group member into a collective awareness of who knows what is needed to help groups make effective and efficient decisions. The higher the level of external turbulence, the greater the positive impact of transactive memory systems on team intuition in decision making. It requires team members with expertise and knowledge as well as connections among those team members so that information/knowledge flows.

**Information processing and team learning**

Teams with a high capacity for organizational learning are a vital antecedent to new product development performance (Meyers & Wilemon, 1989; Purser, Pasmore, & Tenkasi, 1992). The high capacity comes from the team's ability to deliberate and to overcome the fear of being punished.

Deliberation enables teams to come together to acquire, share, interpret and retrieve the knowledge they need and integrate that new knowledge with the existing knowledge base (Purser et al., 1992). Sharing of knowledge on customers, suppliers and internal capabilities has been shown to enhance process performance as well as time to market and value to customers (Hong, Nahm, et al., 2004).

Team learning is most effective when there is agreement among the various constituents about the underlying situation (Purser et al., 1992). Success in team learning also requires the team to overcome their fears when surfacing problems and challenging long held beliefs (Meyers & Wilemon, 1989). In essence, successful learning is an antecedent to new product development performance, occurs in environments with low equivocality and requires team members to overcome fear of repercussions from others that the new knowledge may create.

External turbulence generally creates a high volume of new information that the product development team must interpret (Akgün et al., 2006). In doing so, the product development team must first unlearn old ideas and beliefs if it is to learn from the new information. Teams that unlearn old ideas launch products with a higher probability of success (Michael & Palandjian, 2004). However, teams find it harder to learn from experience as experience grows.

It is the process of deliberation that determines whether the team can be successful at learning from the new information (Akgün et al., 2012). In deliberation, Akgün et al. (2012) found there are multiple communication pathways between constituents for information to travel. In stable, low turbulence environments, this "information distribution redundancy" means information travels at greater speed and positively impacts the team's ability to adapt and learn about the environment. As external turbulence increases, the redundant information pathways between constituents are overloaded due to equivocality. With the overload, new information becomes lost or distorted.

Team members are not always aware of or knowledgeable on external events. Leaders should promote changes in beliefs and routines when rapid changes in the external environment from turbulence affect new product development projects (Akgün et al., 2006). To reduce equivocality, leaders should take advantage of the stressful environment and anxiety to encourage team members to revise their previous beliefs and routines. Leaders should break established team mental models and project infrastructures by approving changes in actions, encouraging new behaviors and reducing the sense of fear for speaking up.

Team learning did not counteract the effects of external turbulence. While learning is an antecedent to counteracting external turbulence, the deliberation and sharing processes of team learning by themselves become overloaded in the presence of external turbulence. In stable markets, an organization can benefit from team learning, but in the presence of external turbulence, you may need to do something different. Determining those alternatives is the topic of this research.

***Slack resources.*** Slack resources available to the new product development team have been shown to have an inverse, U-shaped relationship to new product development success (Nohria & Gulati, 1996). Too little slack is detrimental to new product development success because it discourages any kind of experimentation when success is uncertain. Equally, too much slack is unfavorable because it breeds complacency and a lack of discipline that can lead to more bad projects pursued than good.

It is not just the availability of slack resources that lead to favorable project outcomes, but how the slack resources are applied. Slack resources should be applied to distal search activities; that is, searching for information outside the current knowledge domain of the firm (Miles et al., 1978; Spanjol et al., 2012; Troilo, De Luca, & Atuahene-Gima, 2014). It is especially important in defender firms that have market leading products to be searching in distant market and technological domains to develop knowledge and competencies to move beyond current products.

Slack resources are hypothesized to trigger new product development performance in the presence of external turbulence by improving the processing of information (Bourgeois III, 1981). The availability of slack resources and, especially unabsorbed slack resources, can be applied to unbind and unfreeze knowledge based processes so those processes can deal with the information to address external turbulence.

Slack resources may help counteract external turbulence and do so by providing more capacity for information processing.

***National culture.*** National culture on the new product development team plays a significant moderating role in new product development (Evanschitzky et al., 2012; Souder & Song, 1998; Stace, 1996). New product development processes cannot be generalized across a global organization and successful processes are often culturally specific (Souder & Song, 1998).

The effectiveness of specific management policies depends on national culture and managers wishing to improve new product development performance should select the policies that match the culture in which the new product development team is located (Song, Kawakami, & Stringfellow, 2010).

Different cultural contexts have different antecedents for successful new product initiatives (Stace, 1996). For example, the US uses a decentralized approach with success coming from project managers having high technical, marketing, management and motivational skills (Souder & Song, 1998). Japan uses a style of controlled decentralization where top management makes all the final decisions.

In summary, national culture only exacerbates the effects of external turbulence because the new product development practices used to counteract effects of external turbulence must be shaped to the national culture of the team.

**Information processing and cross functional team leadership**

In counteracting external turbulence, leadership style is important. The continuum of lightweight versus heavyweight product manager is a common taxonomy for describing leadership of cross functional teams used in new product development processes (Clark & Fujimoto, 1991).

A lightweight product manager is generally a lower level functional manager and has a coordinator role within the cross-functional new product development team processes (Clark & Fujimoto, 1991). The lightweight product manager interacts with other liaisons within the cross functional team to collect and process status information, but has little direct contact with subject matter experts, provides only minimal guidance on product direction and commands little influence outside of the cross-functional team.

The heavy weight product manager is at the other end of the continuum and has been shown to deliver the best new product development results in stable markets (Clark & Fujimoto, 1991). In comparison to the lightweight product manager's functionary role, a heavyweight product manager is defined as a set of capabilities, a collection of organizational assets and a group of behaviors needed to lead a cross functional team.

A heavyweight product manager wields more influence and enjoys broader responsibility than traditional product managers towards the lightweight direction on the continuum (Clark & Fujimoto, 1991). Part of their added clout comes from their usually senior position in the organization combined with deep domain knowledge, reputation and broad relationships throughout the organization.

A heavy weight product manager can have a positive impact on the new product performance of cross-functional teams (Clark & Fujimoto, 1991). Leaders who display a relation-oriented leadership style versus the lightweight product manager's functional process oriented style can create a work climate that fosters new product development success (Norrgren & Schaller, 1999). A cross-functional team needs a manager with enough formal and informal influence to effectively lead the team effort (Rauniar, Doll, Rawski, & Hong, 2008). The heavyweight project manager's executive authority, whether actual or associative, may be the quickest way to achieve strategic alignment, shared team mission, and clarity of project targets thereby enabling effective teamwork (Rauniar et al., 2008).

The greater influence of a heavyweight manager is associated with better strategic alignment, a greater sense of shared team mission or purpose, and clearer project targets (Rauniar et al., 2008). Cross-functional teams characterized by diversity and, sometimes, strong functional leaders, need the influence of heavyweight managers to clarify goals and targets and set an environment (lower uncertainty and ambiguity) where everyone can work together more effectively.

***In the presence of external turbulence.*** The heavyweight product manager in the presence of external turbulence can provide the guiding hand. In the fuzzy front-end, a heavyweight product manager's engagement in goal setting improves strategic alignment, shared team mission, and the clarity of project targets which together lead to improved product development performance (Rauniar et al., 2008). The greater the uncertainty and ambiguity in the project context, the more important it is to have a heavyweight product manager who possesses both expertise and formal - informal influence.

Then again, a heavyweight product manager is just that: heavy leadership from the top down. An empowerment style of leadership was found to be more successful in the presence of external turbulence (Frischer, 1993). The style of empowerment is in opposition to the heavyweight, "I know best" style that is characteristic of the heavyweight product manager. Using an empowerment style, managers empower subordinates for the benefit of the whole organization. The organizational climate that is generated better addresses the uncertainties of external turbulence by fostering innovative pursuits.

***Heavyweight product manager and information processing.*** In counteracting external turbulence, leadership style is important. Tellis (2006) found success in overcoming external turbulence requires the leader to have a certain internal mindset and visionary style that may be different from leading in non-turbulent environments. This mindset is an especially important change for the heavyweight product manager. The leader must foster a culture with the right mix of organizational competence, cognitive framing, strategic orientation towards customers and a Schumpeterian view to cannibalizing your existing products.

James (2005) found in an Australian utility addressing external turbulence, management initially thought it was necessary to manage rapid and radical change using a directive - coercive manner. They believed the adoption of a more collaborative method would be too time consuming and ineffective. The results found that in order to overcome resistance to change, the leader must adopt a directive / consultative style. The leader must create the proper attitude; over-communicate about the change; set a good example; solicit opinions from all and reward acceptance. The heavyweight project manager style can be successful in stable environments, while it may be counterproductive in the presence of external turbulence if the heavyweight project manager does not understand the changes in leadership style that may be necessary to counteract turbulence.

**Information processing and the resource based view**

As previously mentioned, the resource based view addresses external turbulence through the concept of dynamic resources that firms use for new resource configurations as markets emerge, collide, split, evolve and die (Eisenhardt & Martin, 2000; El Shafeey & Trott, 2014; Teece et al., 1997).

This transformation in resource configurations occurs through the information processing environment. Senior management is responsible for the integration and dispersion of information about external activities and new technologies (Grant, 1996; Kleinschmidt et al., 2007). In the presence of external turbulence, this "competence to build new competences" applies the dynamic resources necessary to perform environmental scanning and address external turbulence (Danneels, 2008; Eisenhardt & Martin, 2000). It is the learning through environmental scanning that allows the firm to fully benefit from its other rare, non-imitable, and non-substitutable capabilities in turbulent environments (Grant, 1996; Kleinschmidt et al., 2007).

In the context of this research, the execution of the "competence to build new competences" occurs in the information processing environment and is the activity the resource based view uses to reduce uncertainty and resolve the equivocality that accompanies external turbulence.

### Information processing and strategic orientation

In applying a strategic orientation, the information processing environment shows how the strategic orientation is affected by external turbulence. In the default market orientation, the competent processing of market intelligence is considered an antecedent to success; however, that relationship has been found to only hold in stable markets (Citrin, Lee, & McCullough, 2007; Jimenez-Jimenez et al., 2008; Parry & Song, 2010). In turbulent markets, firms need to change how they gather and process information in order to maximize new product outcomes. Instead of the focus on just market issues, information processing should target all orientations areas: market, technology and competitors (Droge et al., 2008; Parry & Song, 2010).

Some research found the opposite result, where the information processes used in applying an effective market orientation does so by reducing the downstream process inertia generated by external turbulence (Koo, Song, Kim, & Nam, 2007; Verganti & Buganza, 2005). A turbulent market causes leaders to pay attention to their environments and define the current trends (Koo et al., 2007).

### Origin of the information processing environment in the literature

The past few subsections examined how product development teams function at the project level in addressing the information processing environment. This subsection presents how the information processing environment and the two opposing states of uncertainty and equivocality were developed in the literature.

As previously mentioned, the definition of the information processing environment in this research is based on the environment construct from the theory of organizational information processing from (Daft & Lengel, 1986). The literature presented the information processing environment as a moderating the link between external turbulence, organizational process factors and project outcomes (Michael & Palandjian, 2004; Song & Montoya-Weiss, 2001; Song et al., 2001; Souder et al., 1998; Spanjol et al., 2012; Tatikonda & Montoya-Weiss, 2001).

The literature found a state of uncertainty to be a crucial design contingency when new product development processes are in the presence of external turbulence in the fuzzy front end (Bstieler, 2005; Calantone et al., 2003; Carson et al., 2012; Souder et al., 1998). Activities within the information processing environment are measured by their ability to address uncertainty in dealing with situations such as external turbulence (Conrath, 1967; Daft & Macintosh, 1981; Daft & Weick, 1984; Duncan, 1972). When not performed well, activities in the information processing environment to address uncertainty can lead to higher new product development costs because of the challenges in addressing the additional information processing created by external turbulence (Souder et al., 1998). They can negatively impact cross-functional team communication leading to inefficiencies and potentially chaos in the new product development project (Song & Montoya-Weiss, 2001).

Originally in the literature, uncertainty had a much broader meaning that included all concerns about the organization's new product development knowledge repository including vagueness, apprehension, ambiguity, confusion and doubt (Conrath, 1967; Daft & Macintosh, 1981; Daft & Weick, 1984). In analyzing the state of uncertainty, the literature found it to have multiple independent dimensions that affect the new product development process. The dimensions of equivocality and volatility were separated out from uncertainty (Carson et al., 2012; Daft & Macintosh, 1981; March & Olsen, 1975). The presence and level of each element - uncertainty, equivocality and volatility - were found to matter independently in the success of new product development processes.

Applying this decomposition to the fuzzy front end, volatility in the turbulence in the external environment creates uncertainty. The uncertainty exists because the product development team lacks the information needed to understand the changes there. The new product development team utilizes the information processing environment to gather the additional information and, as additional information is gathered, the team may have difficulty resolving equivocality.

Equivocality is the messy, unclear state where the information gathered to address uncertainty may have multiple interpretations within the new product development team (Daft & Lengel, 1986). Even the addition of more information may fail to resolve equivocality. Equivocality is the result of failure in the information processing environment where there is much information, but the activities do not bring the team together on an interpretation of the external environment. It is not a problem with the level of information available but its interpretation.

Therefore, the connection between turbulence and new product development processes in the fuzzy front end is proposed to occur through the information processing environment. It is there that the two opposing states of uncertainty and equivocality resulting from the wave changes and overload of new information generated by external turbulence are addressed (Daft & Lengel, 1986). The information processing environment interprets the external situation, gathers additional information, resolves equivocality and addresses the uncertainty that arises from external turbulence.

External turbulence has never been addressed directly through the lens of information processing environment but only through tangential factors (MacCormack et al., 2001; Tatikonda & Montoya-Weiss, 2001). These factors have included internal characteristics such as team experience and investment in design and external characteristics such as technological novelty, market newness and general external disruption.

To tackle the information processing environment, this research will use the variables of uncertainty and equivocality as described below and included in the research model on page 79.

**Uncertainty**

Uncertainty is the absence of information and, in the context of the information processing environment, the difference between the information required to address an issue in the external environment and the information available (Daft & Lengel, 1986).

The quality of product team decision making in turbulent environments greatly depends on the information available (Glaser & Weiss, 1993). Product development success is shown to be associated with the systematic reduction of decision-making uncertainty (Schulz, 2001; Van Riel, Lemmink, & Ouwersloot, 2004). That reduction in uncertainty comes from organizational information gathering, its diffusion across the team and the information processing activities it generates. Gathering information from outside the organization counteracts the turbulence induced ineffectiveness of team members (Schulz, 2001).

Organizations that face high uncertainty have to ask a large number of question to acquire more information and to learn answers (Daft & Lengel, 1986; Daft & Macintosh, 1981). The new data is acquired so the new product development project is performed under a reduced level of uncertainty (Daft & Lengel, 1986; Daft & Macintosh, 1981). Correspondingly, it is assumed by this idea that the environment is such that organization and it managers can ask questions related to the cause of the uncertainty and obtain answers to those questions (Daft & Lengel, 1986; Daft & Macintosh, 1981).

**Equivocality**

Equivocality means there are multiple conflicting interpretations of the information available (Daft & Lengel, 1986; Daft & Macintosh, 1981). In contrast to uncertainty, equivocality is not lack of data but a lack of clarity about the data (Calantone et al., 2003).

In the information processing environment, equivocality is synonymous with ambiguity and, with high levels of equivocality, there is the confusion and lack of understanding among new product development team members (Daft & Lengel, 1986; Daft & Macintosh, 1981). Asking a yes-no question to resolve equivocality is not feasible. In fact, participants are not even certain about the questions to be asked, and, if questions are asked, the meaning of the answers received.

Theoharakis and Wong (2002) found when adopting new technologies that equivocality is concentrated in the early stages. The information published and gathered is technically intensive and not necessarily congruent from one source to the next. As the technology is embraced and matures, the information matures and moves through a standard cadence of supply-push, product-focus and discontinuation.

## New Product Development Outcomes

The literature review moves from the information processing environment to the final of four sections, new product development outcomes. In this research, financial outcomes, market outcomes and customer satisfaction are the measures used to determine the success of new product development activities. This section of the literature review shows how the existing literature on measuring product development outcomes.

### New product development outcomes defined

The success rate of new product development projects is approximately 59% and best practice firms are more likely to measure new product development performance (Griffin, 1997). Product development outcomes matter to overall firm performance and market valuations are responsive to the success or failure of new product development efforts (A. Sharma & Lacey, 2004).

When determining the success of a new product initiative, much depends on the metric used to measure new product performance (Atuahene-Gima, Slater, & Olson, 2005). For example, the results of a market orientation drop as the measure of performance shifts from new product success to profitability and then to market share (Baker & Sinkula, 2005). Danneels and Kleinschmidt (2001) found financial performance is closely tied to whether the product fits with the firm's existing marketing and technological competences and not whether the product “stays close to home” in terms of target market and technology employed.

For this research, product development outcomes are defined as the project’s actual performance against expectations. The three variables include in this research (financial performance, market performance and customer satisfaction) are shown below and included in the research model on page 79:

| | |
|---|---|
| **Financial performance** | |
| Financial performance is the degree to which the product exceeded or fell short of the expected profitability level | (Cooper & Kleinschmidt, 1987) |
| **Market performance** | |
| Market performance is the extent to which the product exceeded or fell short of achieving market expectations | (Cooper & Kleinschmidt, 1987) |
| **Customer satisfaction** | |
| Customer satisfaction is defined as the level of the purchaser's affective response (negative to positive) for the product | (Syamil et al., 2004) |

**Gap in the literature and research model**

This section summarizes the literature review presented in the past four sections to describe the gap in the literature that this research aspires to address. The literature review just presented explored the existing research on the effects of external turbulence on new product development processes in the fuzzy front end. Considerable attention was devoted to the common thread of information processing challenges created by high levels of external turbulence.

**Gap in literature**

In exploring the antecedents to new product development success (strategic orientation, the resource based view, strategic planning, senior management support, cross functional teams and others), this literature review found a bias towards stable markets. Little consideration was given to external turbulence, the velocity of markets and similar factors. When external turbulence was addressed, the same fuzzy front end activities that were successful in stable environments often failed in the presence of external turbulence as follows:

| | |
|---|---|
| Strategic orientation: | In applying a strategic orientation in the presence of external turbulence, information gathering mattered more than the orientation chosen. |
| Resource based view: | To address external turbulence, the resource based view required the addition of dynamic resources and the redefinition of long-term competitive advantage to be a series of short-term advantages. |
| Strategic planning: | The rote thinking that is induced by strategic planning may blind the organization from understanding the external turbulence induced changes affecting their firm. |
| Cross functional teams: | Cross functional teams, the bedrock of new product development execution, can be overwhelmed by external turbulence. |

When the failures of these antecedents to new product success were considered in the literature, the recommendation generally involved gathering additional information from a broader group of constituent sources about the causes and consequences of turbulence in the external environment. Those sources include customers, suppliers, regulatory bodies, industry groups, consultants, integrators and others.

Flexible new product development practices were proposed that generate information from new sources and respond to new information for a longer proportion of the new product development project. While research has been performed on flexible new product development practices, there is no consensus on their ability to counteract external turbulence. Some research has found their usage generates a tradeoff with product cost and quality, is only applicable in high velocity industries or contingent upon specific market conditions.

The flexible practices have not been evaluated by their ability to process the considerable amount of new information generated by external turbulence. This shortcoming is an important gap in the literature that this research aspires to address. Traditional sequential new product development processes failed to address the wave of changes and overload of information in the presence of external turbulence. Therefore, understanding how the flexible replacement practices handle this information overload is important to the development of successful new products.

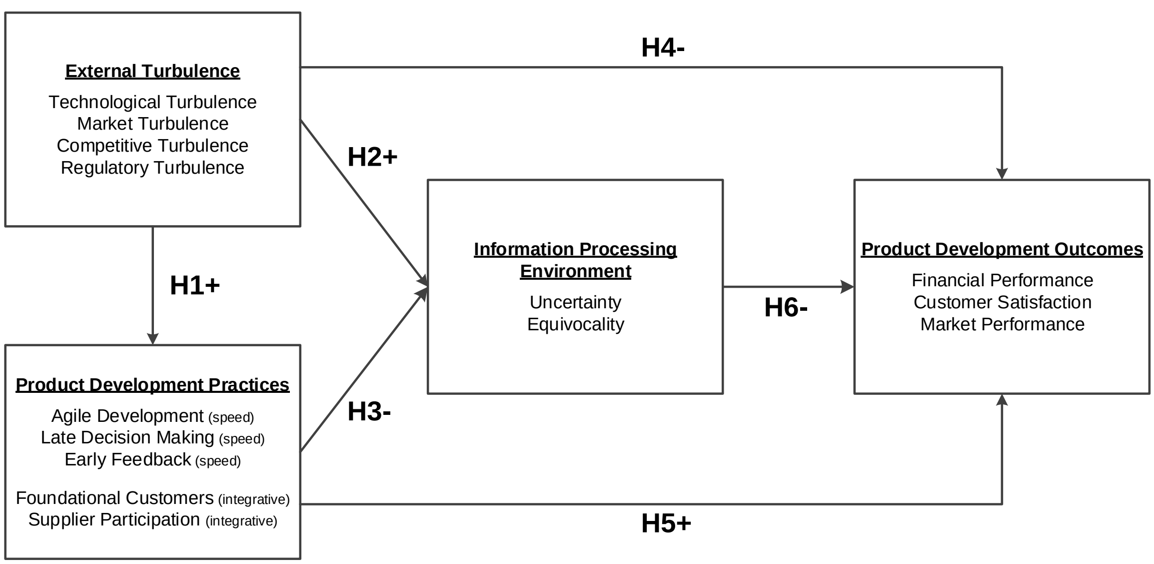
The information processing to counteract external turbulence occurs in the information processing environment and it is the incorporation of the information processing environment in the research model (page 79) that is the fresh approach this research aspires to apply. The definition of the information processing environment is derived from the Daft and Lengel (1986) theory of organizational information processing. Its application to understanding the effectiveness of flexible product development practices continues the work of Hong, Nahm, et al. (2004), Koufteros et al. (2002) and Zhang and Doll (2001).

External turbulence is coming from more sources, is arriving with greater frequency and is creating a wave of changes in the organization's external environment that must be addressed by the organization's new product development team to ensure the desired new product development outcomes are achieved.

## Research model

The model for this research is shown in figure 4 below and consists of four components: external sources of turbulence, product development practices, the information processing environment and product development outcomes.

*Figure 4: Research model*




***External turbulence.*** External turbulence is the independent variable that is affecting the dependent variable, product development outcomes. Four types of external turbulence are included in this research: technological turbulence (page 39), market turbulence (page 39), competitive turbulence (page 40) and regulatory turbulence (page 40).

***Product development practices.*** Product development practices and especially the flexible practices included in this research are mediator variables intended to address the challenges created by external turbulence. Two categories of flexible practices are included: process speed and integrative practices. Practices for process speed included in this research are agile development (page 49), early feedback (page 50) and late decision making (page 50). Integrative practices included in this research are foundational customers (page 53) and supplier participation (page 54).

***Information processing environment.*** The information processing environment is a mediator variable that is intended to explain why a product development practice addresses a type of turbulence coming from the firm's external environment. The two opposing states of uncertainty (page 73) and equivocality (page 74) are included in this variable.

***Product development outcomes.*** Product development outcomes are the independent variable used to measure the success of new product development activities. In this research, the product development outcomes used are financial performance (page 15), market performance (page 15) and customer satisfaction (page 15).

**Hypotheses development**

***External turbulence and product development practices.*** New product development teams experiencing high levels of external turbulence will be more likely to use process speed and integrative practices to counteract the effects of the external turbulence.

Traditionally, new product development processes used a sequential methodology where fuzzy front-end activities are organized into sequential process steps. Each step settles a certain aspect of the new product initiative before moving onto the next step. While a sequential methodology has been shown to be effective in stable environments, its rigid structure has failed in addressing the higher velocity of changes generated by external turbulence.

Flexible new product development practices were proposed to respond to new information for a longer proportion of the new product development lifecycle. By having a longer window to respond to change before the design freeze, flexible practices increase the ability of new product development processes to react to unexpected changes and diminish the likelihood of the newly released product or service becoming obsolete soon after launch.

***H1:*** *External turbulence is positively related to the use of integrative practices and compression techniques.*

***External turbulence and the information processing environment.*** Turbulence in the external environment generates a wave of changes and a high volume of new information for the new product development team to process. The result of external turbulence can invalidate existing information in new product development team's knowledge store.

Uncertainty increases because the product development team lacks the information needed to understand the external changes and rebuild its knowledge store.

Therefore, the new product development team must gather additional information to reduce uncertainty. As additional information is gathered, the team may have difficulty resolving equivocality across the team. Equivocality occurs when the information gathered to address uncertainty may have multiple interpretations within the new product development team and even the addition of more information may fail to resolve the equivocality.

***H2:*** The greater the level of external turbulence, the more uncertainty and equivocality in the information processing environment.

***Product development practices and the information processing environment.*** Product development practices used within the organization must address the wave of changes created by external turbulence. Legacy sequential new product development processes were shown to be effective in stable environments but ineffective in the presence of external turbulence.

Flexible practices in new product development were proposed to counteract external turbulence by their ability to incorporate and respond to new information for a longer proportion of the new product development lifecycle.

Turbulence in the external environment is expected to increase uncertainty and equivocality in the information processing environment. The use of flexible practices is presumed to lower the uncertainty and equivocality created by external turbulence.

***H3:*** The more the use of flexible new product development practices, the less uncertainty and equivocality in the information processing environment.

In turbulent external environments with a high velocity of new information, the future value of any piece of information is diminished. Quickly processing new information into the product design decreases the risk that the information will become stale before the product is released and new rounds of information gathering are required. Techniques for process speed quicken the pace of activities in the fuzzy front end and are thereby expected to reduce uncertainty in the information processing environment.

***External turbulence and product development outcomes.*** External turbulence upsets the experience-based processes used in new product development thereby reducing the expected successful product development outcomes.

***H4:*** The level of external turbulence is negatively related to achieving product development outcomes.

***Product development practices and product development outcomes.*** Product development practices are intended to counteract the effects of external turbulence and deliver the product development outcomes expected.

***H5:*** The use of integrative practices and process speed techniques is positively related to achieving product development outcomes.

***Information processing environment and product development outcomes.*** The information processing environment consists of the information processing that counteracts the effects of external turbulence. When external turbulence increases the level of uncertainty and equivocality in the information processing environment, the new product development team has greater difficulties in achieving the product development outcomes.

***H6:*** The more uncertainty and equivocality in the information processing environment, the lower the product development outcomes

# CHAPTER III

## Methodology

This chapter describes the methodology used in this research study. Topics addressed include the target sample definition, structured interview collection, pilot study data collection, measure creation and full research study data collection.

### Target Sample

The target industry for this research is healthcare. The choice reflects the fact that the healthcare industry globally and especially in the United States is undergoing much change. Respondents are drawn from members of HIMSS, the Healthcare Information Management Systems Society. HIMSS is a global healthcare IT industry association with over 52,000 individuals primarily employed by healthcare providers, governmental agencies and not-for-profits (http://www.himss.org/himss-faqs).

The unit of analysis for this research is a distinct product development project that has completed within the past ten years no matter whether the outcome was successful, unsuccessful or somewhere in between. Respondents must have participated in the reported product development project for most of its existence and held an appropriate role in delivering the project. The respondent screening questions are shown in appendix A (page 127).

**Structured Interviews**

The structured interviews were used as the first test of the model. In the early stage of model development, it was imperative to verify the variables capture the meaning of their construct (Churchill, 1979). In the structured interview, typical HIMSS members were asked a series of questions about each variable to determine whether these typical respondents understood the meaning of the variables in the research model proposed. The structured interview question script is shown in appendix B (page 129).

Four structured interviews were completed. The respondents were HIMSS members working in software companies that offered products in support of healthcare operations. Of the four respondents, all but one held a Vice President title. The non-VP person held a senior technical leadership position and was also a co-chair of one of the ANSI-X12 sub-committees for healthcare messaging standards.

Three of the respondents were part of their companies' product management organization and the remaining respondent (has VP title) was part of his/her company's development organization. The interview with the development VP was not successful. The respondent kept returning to a discussion of the project's technical construction phase even though all the questions were about the project's fuzzy front end.

As each question was asked during the structured interview, it was obvious whether the respondent did or did not understand the variable's meaning by the first story they told in response to each question. Of the three product management respondents, their stories were relevant to the variable definitions and confirmed their understanding of the variables.

**Pilot Study**

A pilot study was performed to test the response collection technology and to test an early draft of the measure.

Fifty-five full responses were collected from the field of healthcare. Of the fifty-five responses, eleven respondents were from the author's employer, IBM Corporation. An additional nine responses were collected from the financial services industry but were not used.

Respondents were invited to complete the survey using an email invitation shown in appendix C (page 146). The email directed respondents to a landing page that had additional information about the research and a link to the survey engine. One follow-up email was sent to non-responders of the first email.

The invitation email was created from an A-B testing exercise with a group of IBM product leaders. Two thousand invitations were sent to the HIMSS members that were not IBM employees and forty-four responses were received, giving a 2% response rate for general HIMMS members.

The draft measure used in the pilot study included ninety-three questions, far more questions than expected to be used in the large-scale study. The pilot study responses were analyzed to eliminate the worst performing questions and to winnow the measure down to an acceptable count. The pilot study draft measure and the disposition of each question is shown in appendix D (page 148).

The analysis performed on the pilot study data consisted of the following tests: descriptive statistics, reliability of the variables using Cronbach's Alpha, question purification using corrected item-total correlation, unidimensionality using exploratory factor analysis and validity using confirmatory factor analysis. The following sections summarize the results of each test.

**Pilot study descriptive statistics**

A summary of the descriptive statistics is shown in appendix E (page 153). The response distributions were not normal; however, the responses were not expected to be normal distributions given the homogeneity of the respondent population. All respondents were primarily involved in US healthcare organizations.

The responses to some questions showed significant skewness and kurtosis. Those items are marked as significant in the detail shown in appendix E (page 153). As with normality, the asymmetry of the responses likely results from the homogeneity of the respondent population. Significance for skewness and kurtosis was calculated by dividing the skewness or kurtosis by its standard error and determining whether that result was significantly different from zero (alpha = 5%).

**Pilot study reliability**

Reliability refers to how closely the questions assigned to each variable act as a group and repeatedly measure the same phenomenon without much variation (Nunnally & Bernstein, 1978; Tavakol & Dennick, 2011). Reliability was examined using Cronbach's alpha. The summary by variable is shown in figure 5 below and the detail by question is shown in appendix F (page 160).

Values between .70 and .95 are considered acceptable (Nunnally & Bernstein, 1978; Tavakol & Dennick, 2011). Values below .7 suggest all questions are not measuring the same construct while values above .95 suggest the questions could be redundant. In addition, the number of questions is important in evaluating the statistic. If the number of questions is too low, the statistic may underestimate reliability. Five or more questions is considered adequate.

In figure 5 below, the "start" columns show the number of questions in the Pilot Study measuring that variable and the "start" Cronbach's Alpha statistic. The "end" columns show the number of questions that would remain if questions were removed that would improve reliability and the "end" Cronbach's Alpha statistic reflecting their removal.

*Figure 5: Cronbach's Alpha results by variable for the pilot study*

| Variable | Start | | End | |
|---|---|---|---|---|
| | Questions | Cronbach's Alpha | Questions Remaining | Cronbach's Alpha |
| Technological Turbulence | 6 | 0.677 | 5 | 0.683 |
| Market Turbulence | 9 | 0.772 | 8 | 0.772 |
| Competitive Turbulence | 9 | 0.827 | 6 | 0.856 |
| Regulatory Turbulence | 11 | 0.810 | 5 | 0.932 |
| Foundational Customers | 7 | 0.870 | 6 | 0.873 |
| Supplier Participation | 7 | 0.983 | 5 | 0.986 |
| Agile Development | 9 | 0.873 | 8 | 0.875 |
| Early Feedback | 7 | 0.785 | 6 | 0.798 |
| Late Decision Making | 7 | 0.897 | 7 | 0.897 |
| Product Development Outcomes | 10 | 0.846 | 7 | 0.867 |
| Uncertainty | 6 | 0.943 | 6 | 0.943 |
| Equivocality | 5 | 0.938 | 5 | 0.938 |
| Totals | 93 | | 74 | |

Cronbach's Alpha suggests there is reliability in the survey. With the exception of technological turbulence, all results for Cronbach's Alpha were above the .7 threshold for both the “start” and “end” columns. Technological turbulence was only a small amount below the .7 threshold.

**Pilot study purification**

Corrected Item Total Correlation (CITC) was used for purification analysis. CITC analyzes whether the questions assigned to each variable have responses that correlate with the other questions assigned to that variable (DeVellis, 2012). If a question does not correlate to its variable group, then that question is a candidate to be discarded. Questions measuring a variable should have a correlation of .60 or higher. Questions with a correlation between .50 and .60 were reviewed for content and appropriate wording. Items with a correlation below .50 are candidates for deletion unless there is a compelling reason to keep them in the variable group.

CITC is performed iteratively to obtain the highest level of correlation for each variable. That is, the questions that are candidates for deletion are removed until the highest level of correlation for the questions assigned to a variable are obtained.

Appendix F (page 160) shows the results of CITC analysis applied to the pilot study data. Technological turbulence and market turbulence showed the lowest correlation but were considered sufficiently close to be acceptable.

Based on the number of questions that could be eliminated from redundancy or poor measurement of the variable in question, the survey could be made 20% smaller thereby improving the likelihood that respondents answer all questions.

**Pilot study unidimensionality**

Exploratory factor analysis (EFA) was used for the assessment of unidimensionality of each scale (DeVellis, 2012; Nunnally & Bernstein, 1978; Weiss, 1970). Discriminant validity is achieved when there is an absence of correlations between factor loadings of unrelated items (DeVellis, 2012; Pitt, Watson, & Kavan, 1995; Venkatraman, 1989). When applied to this research, discriminant validity is substantiated when each pair of variables loads on its intended factor. When a variable does not load on its intended factor or loads on another, it is a candidate for deletion or modification.

Exploratory factor analysis was attempted but the pilot study had an insufficient number of responses for a positive definite sample correlation matrix. Regardless, the full rotated component model is shown in appendix G (page 165).

**Confirmatory factor analysis.**

The model was built for confirmatory factor analysis using AMOS, however the pilot study had an insufficient number of results to estimate the model. Regardless, estimation was forced using the "Allow non-positive definite sample covariance matrices" flag.

## Final Measure Creation

The goal in measure creation is the development of a measure with desirable validity, desirable reliability and a construction that is appropriate for the research intended (Churchill, 1979). Based on the tests performed on the pilot study data, the 93 pilot study questions were winnowed down to the measure used in the full research. The following table shows a summary of the question purification and appendix D (page 148) has the detail by question as follows:

*Figure 6: Question purification summary – pilot study to full research*

| Variable | Pilot Study Question Count | Full Research Question Count |
|---|---|---|
| Technological Turbulence | 6 | 5 |
| Market Turbulence | 9 | 5 |
| Competitive Turbulence | 9 | 5 |
| Regulatory Turbulence | 11 | 5 |
| Foundational Customers | 7 | 4 |
| Supplier Participation | 7 | 4 |
| Agile Development | 9 | 4 |
| Early Feedback | 7 | 4 |
| Late Decision Making | 7 | 4 |
| Product Development Outcomes | 10 | 4 |
| Uncertainly | 6 | 5 |
| Equivocality | 5 | 5 |
| Demographics | 0 | 7 |
| Totals | 93 | 59 |

The origin of each question measuring each variable is shown in the following sections. The detail includes the question text and the source reference from the literature. Unless mentioned, the questions used a five-point Likert scale with steps from “To no extent” to “To some extent” to “To a large extent”.

## External sources of turbulence

Questions in this section ask about the characteristics of external sources of turbulence occurring during the time the project being reported was active.

***Technological turbulence.*** Technological turbulence is defined as the rate of technological change. This definition comes from Jaworski and Kohli (1993) and Calantone et al. (2003). The questions were drawn from:

T1 The technology changed rapidly — *Source:* Jaworski and Kohli (1993)

*Text from source:* The technology in our industry is changing rapidly

T2 Technological improvements provided big opportunities — *Source:* Jaworski and Kohli (1993)

*Text from source:* Technological changes provide big opportunities in our industry

T3 Forecasting the state of technology five years forward was difficult — *Source:* Jaworski and Kohli (1993)

*Text from source:* It is very difficult to forecast where the technology in our industry will be in the next 2 to 3 years

T4 Technological breakthroughs led to new products — *Source:* Jaworski and Kohli (1993)

*Text from source:* A large number of new product ideas have been made possible through technological breakthroughs in our industry

T5 The modes of production and service change often — *Source:* Calantone et al. (2003)

*Text from source:* In our principal industry, the modes of production and service change often

***Market turbulence.*** Market turbulence is defined as the rate of change in customer preferences. This definition comes from Jaworski and Kohli (1993) and Calantone et al. (2003). The questions were drawn from:

M1 Customer product preferences were changing — *Source:* Jaworski and Kohli (1993)

*Text from source:* In our kind of business, customers' product preferences change quite a bit over time

M2 Customer demand was difficult to forecast — *Source:* Calantone et al. (2003)

*Text from source:* Demand and customer tastes are fairly easy to forecast

M3 Customer preferences were difficult to forecast — *Source:* Jaworski and Kohli (1993)

*Text from source:* Demand and customer tastes are fairly easy to forecast

| | | |
|---|---|---|
| M4 | Customers were looking for new products<br>*Text from source:* Our customers tend to look for new products all the time | *Source:* Jaworski and Kohli (1993) |
| M5 | New customer needs were often different from existing customer needs<br>*Text from source:* New customers tend to have product-related needs that are different from those of existing customers | *Source:* Jaworski and Kohli (1993) |

***Competitive turbulence.*** Competitive turbulence considers the ability of competitors to thwart your market actions. This definition comes from Jaworski and Kohli (1993). The questions were drawn from:

| | | |
|---|---|---|
| C1 | Competition in our industry was intense<br>*Text from source:* Competition in our industry is cutthroat | *Source:* Jaworski and Kohli (1993) |
| C2 | Competitors readily matched out actions<br>*Text from source:* Anything one competitor can offer, others can match readily | *Source:* Jaworski and Kohli (1993) |
| C3 | New competitors regularly entered our industry<br>*Text from source:* It is easy for new players to enter our industry | *Source:* Paladino (2008) |
| C4 | New competitive actions occurred regularly<br>*Text from source:* One hears of a new competitive move almost every day | *Source:* Jaworski and Kohli (1993) |
| C5 | Competitor market shares changed rapidly<br>*Text from source:* In general, in this business unit (or division), market share is stable among the same competitors | *Source:* Calantone et al. (2003) |

***Regulatory turbulence.*** Regulatory turbulence is defined as high regulatory fluctuation and stringency This definition comes from Wijen and Van Tulder (2011). No existing measure was found for regulatory turbulence so the questions were created from the assessment components described as part of the regulatory turbulence tool defined by Wijen and Van Tulder (2011). Their tool is intended to suggest a strategy to address regulatory turbulence.

| | | |
|---|---|---|
| R1 | Our industry had stringent regulations | *Derived From:* Wijen and Van Tulder (2011) |
| R2 | Regulatory changes shaped our business | *Derived From:* Wijen and Van Tulder (2011) |
| R3 | Regulations were uncertain | *Derived From:* Wijen and Van Tulder (2011) |
| R4 | Our home country regulations impede our ability compete in other countries | *Derived From:* Wijen and Van Tulder (2011) |
| R5 | New markets had more stringent regulations than our home country | *Derived From:* Wijen and Van Tulder (2011) |

**Internal product development practices**

Questions in this section ask about the internal product development practices employed within the project reported.

***Foundational customers.*** The variable, foundational customers, is defined as customer representatives who participate in the new product development process and help shape the requirements. The definition comes from Carbonell et al. (2009) and Gatignon and Xuereb (1997). The questions were drawn from:

| | | |
|---|---|---|
| F1 | Customers served on the project team<br>*Text from source:* Specific customers were invited to join the project as team members | *Source:* Carbonell et al. (2009) |

| | | |
|---|---|---|
| F2 | Customers on the project team influenced the product concept<br>*Text from source:* Users are always involved early—typically during product definition | *Source:* Moultrie, Clarkson, and Probert (2007) |
| F3 | Customers on the project team contributed to product specifications<br>*Text from source:* Customer input is critical and more important in the front-end stages | *Source:* Alam (2006) |
| F4 | Customers on the project team described their expected use of this product<br>*Text from source:* Please rate the extent to which your lead users are involved in the following activities: Setting general product definition, setting product specifications, overall new product development process | *Source:* Al-Zu'bi and Tsinopoulos (2012) |

***Supplier participation.*** Supplier participation is defined as the roles that suppliers play in the product development process. This definition comes from Cusumano and Takeishi (1991). The questions were drawn from:

| | | |
|---|---|---|
| S1 | Suppliers participated on the project team<br>*Text from source:* How extensive was the supplier's participation on your firm's project team for this project? | *Source:* Ragatz et al. (2002) |
| S2 | Employees and project team members communicated directly<br>*Text from source:* How much direct cross-functional/inter-company communication (for example, engineer to engineer) took place between your firm and the supplier's firm during the project? | *Source:* Ragatz et al. (2002) |
| S3 | Suppliers were involved in the early stages of this project<br>*Text from source:* How long was this supplier involved: % of the total project duration | *Source:* Hoegl and Wagner (2005) |

| | | |
|---|---|---|
| S4 | We made use of supplier expertise in the development of this project<br>*Text from source:* Please rate the extent to which your suppliers are involved in the following activities: setting general product definition, setting lead time requirements, setting product specifications, overall new product development process | *Source:* Al-Zu'bi and Tsinopoulos (2012) |

***Agile methodology.*** Agile methodology is defined as rapid development iterations to gain feedback combined with overlapping processes where the next iteration begins before the current iteration finishes. This definition comes from Mohan et al. (2010) and Zhang and Doll (2001). No existing measures for agile development were found. The questions shown were created from the agile principles published by the Agile Alliance (http://www.agilealliance.org).

| | | |
|---|---|---|
| A1 | We used rapid development iterations<br>*Agile principle:* Agile projects are structured around a series of iterations of fixed calendar length | *Created from:* Agile principles (http://www.agilealliance.org) |
| A2 | We used overlapping design iterations<br>*Agile principle:* Agile teams favor an incremental development strategy that each successive version of the product is usable | *Created from:* Agile principles (http://www.agilealliance.org) |
| A3 | We welcomed changing requirements even late in the product development process<br>*Agile principle:* Welcome changing requirements, even late in development | *Created from:* Agile principles (http://www.agilealliance.org) |
| A4 | We communicated using the richest means available<br>*Agile principle:* The most efficient and effective method of conveying information to and within a development team is face-to-face conversation | *Created from:* Agile principles (http://www.agilealliance.org) |

***Early feedback.*** Early feedback is defined as regularly gathering feedback from multiple internal constituents at the earliest stages of the product development process.

This definition comes from Buganza et al. (2009), Lakemond et al. (2013) and Narasimhan et al. (2006). The questions were drawn from:

| | | |
|---|---|---|
| E1 | We involved many internal stakeholders in the product development project<br>*Text from source:* Many different actors are involved in product development and production | *Source:* Lakemond et al. (2013) |
| E2 | We aligned project objectives and incentives across all teams<br>*Text from source:* There is a great difference in objectives, incentives, working procedures, etc., between the actors carrying out product development and those involved with production | *Source:* Lakemond et al. (2013) |
| E3 | Team members had many opportunities for interaction across all internal groups<br>*Text from source:* To what extent do people in different departments meet in different settings (conference, projects) to discuss different issues related to the organization (such as, new product development, planning, operations management) | *Source:* Akgün et al. (2012) |
| E4 | Team members were encouraged to exchange opinions/ideas<br>*Text from source:* To what extent do people in different departments have resource exchange to solve organizational related problems? | *Source:* Akgün et al. (2012) |

***Late decision making.*** Late decision making is defined as waiting until the last phases of the product development process to freeze product concepts, capabilities and designs. This definition comes from Buganza et al. (2009). The questions are drawn from:

| | | |
|---|---|---|
| L1 | We developed multiple prototypes throughout the front-end process<br>*Text from source:* Rapid prototyping is used | *Source:* (Narasimhan et al., 2006) |

| | | |
|---|---|---|
| L2 | We made design decisions as late as possible<br>*Text from source:* Objections or additions to our development plans were welcomed at any point, even if they arrived after we thought we had reached agreement on a final decision | *Source:* (Carson et al., 2012) |
| L3 | We performed experiments involving customers throughout the product's development<br>*Text from source:* Users involved throughout idea generation, concept selection, and evaluation of prototypes | *Source:* (Moultrie et al., 2007) |
| L4 | We postponed product design freeze until the final iteration<br>*Text from source:* We didn't freeze the concept | *Source:* (Buganza et al., 2009) |

**Information processing environment**

Questions in this section ask about the quantity and quality of the information available to the product development team in the early stages of the project being reported.

***Uncertainty.*** Uncertainty is defined as the absence of information. This definition comes from Daft and Lengel (1986). The questions were drawn from Park (2011):

| | | |
|---|---|---|
| U1 | The information needed for product development was of uncertain usefulness<br>*Text from source:* The information available early on for initial project planning was of uncertain usefulness | *Source:* Park (2011) |
| U2 | The information needed for product development was too vague to be very helpful<br>*Text from source:* The information available early on for initial project planning was too vague to be very helpful | *Source:* Park (2011) |

| | | |
|---|---|---|
| U3 | The information needed for product development was perceived as too inaccurate<br>*Text from source:* The information available early on for initial project planning was perceived as too inaccurate | *Source:* Park (2011) |
| U4 | The information needed for product development was incomplete for our needs<br>*Text from source:* The information available early on for initial project planning was incomplete for our task | *Source:* Park (2011) |
| U5 | The information needed for product development did not exist<br>*Text from source:* The information available early on for initial project planning was missing important details | *Source:* Park (2011) |

***Equivocality.*** Equivocality means there are multiple conflicting interpretations of the information available. This definition comes from Daft and Lengel (1986) and Daft and Macintosh (1981). The questions were drawn from Park (2011):

| | | |
|---|---|---|
| V1 | The information needed for product development was ambiguous<br>*Text from source:* The information available early on for initial project planning was ambiguous | *Source:* Park (2011) |
| V2 | The information needed for product development had multiple interpretations<br>*Text from source:* The information available early on for initial project planning had multiple interpretations | *Source:* Park (2011) |
| V3 | The information needed for product development was interpreted differently by team members<br>*Text from source:* The information available early on for initial project planning was interpreted differently by team members | *Source:* Park (2011) |
| V4 | The information needed for product development had conflicting interpretations<br>*Text from source:* The information available early on for initial project planning had conflicting interpretations | *Source:* Park (2011) |

V5 The information needed for product development was confusing because of different interpretations — *Source:* Park (2011)

*Text from source:* The information available early on for initial project planning was confusing due to different interpretations

**Product development outcomes**

This section asks questions about the reported project's actual financial performance, market performance and customer satisfaction against expectations. The questions were drawn from:

O1 Sales relative to expectations — *Source:* Moorman and Miner (1997)

*Text from source:* Sales relative to objective

O2 Profit margin relative to expectations — *Source:* Moorman and Miner (1997)

*Text from source:* Profit margin relative to objective

O3 Customer satisfaction relative to expectations — *Source:* Hoonsopon and Ruenrom (2012)

*Text from source:* Customers' satisfaction with the new product meets the company's target

O4 Market share relative to expectations — *Source:* N. Kim and Atuahene-Gima (2010)

*Text from source:* Market share relative to objectives

**Demographics**

A demographic section with seven questions was added to the measure used for the full research. Demographic questions were not included in the pilot study. The demographic questions added, and the respondents' answer choices are shown below:

D1 Year of project completion

− 2014 to 2017
− 2011 to 2013
− 2008 to 2010
− 2005 to 2007
− Older

D2 Your professional role in this project

- Design, Engineering, Product Development
- Marketing / Sales
- Clinical Management
- IT / Systems Management
- General and Financial Management
- Researcher, Professor, Educator
- Government, Public Servant
- Other

D3 Project leadership was primarily located in the following geography

- Africa Central
- Africa Eastern
- Africa Northern
- Africa Southern
- Africa Western
- Asia Eastern
- Asia Southeast
- Asia Southern
- Asia Western
- Commonwealth of Independent States (CIS)
- Oceania
- Europe Other
- Europe Union
- North America
- Caribbean Islands
- Central America
- South America

D4 How many employees were in the organization

- Below 2,000
- 2,000 to 4,999
- 5,000 to 7,999
- 8,000 to 10,999
- 11,000 to 13,999
- 14,000 to 16,999

D5 Was this project expected to deliver an incremental update or an innovative new project (five point Likert scale as follows)

- Incremental Update
- Balanced Release
- Innovative New Product

D6 What was the project size relative to other projects in this company (five point Likert scale as follows)

- Smaller
- Similar
- Larger

D7 What was the project risk relative to other projects within this company (five point Likert scale as follows)

- Smaller
- Similar
- Larger

**<u>Full Research Data Collection</u>**

For the full research, data was collected from respondents using two methods - 512 responses using the Qualtrics LLC service and 81 responses by a stand-alone implementation of the open source survey tool called Survey Project (http://surveyproject.org/). Both methods used the identical survey and the response sets from both methods were combined for the analysis.

**Full research coarse response quality tests**

Coarse response quality tests were run on the combined data set and were intended to eliminate responses that were not authentic. The coarse response quality tests included tests for pattern based answers, answer runs and unusual number of answers from the same location or network. A total of thirty responses were eliminated by the coarse response quality tests. Thus, a total of 563 responses moved forward as the dataset for the analysis.

The next set of tests repeated the analysis process used for the pilot study data—descriptive statistics, a reliability test and question purification.

**Full research descriptive statistics**

The descriptive statistics for the full research showed similar characteristics as was shown in the pilot study. A summary of the descriptive statistics is presented in appendix H (page 168). Like the pilot study, the response distributions were not normal. This outcome is attributed to the homogeneity of the respondent population. As shown in figure 7, the projects reported by over sixty percent of the respondents were led from the United States. Full demographic results are shown in appendix J (page 177).

*Figure 7: Project leadership by geography*

| Location | Responses | Percent |
|---|---|---|
| Africa Central | 11 | 2.0% |
| Africa Eastern | 3 | 0.5% |
| Africa Northern | 2 | 0.4% |
| Africa Southern | 3 | 0.5% |
| Africa Western | 0 | 0.0% |
| Asia Eastern | 2 | 0.4% |
| Asia Southeast | 12 | 2.1% |
| Asia Southern | 10 | 1.8% |
| Asia Western | 6 | 1.1% |

| Location | Responses | Percent |
|---|---|---|
| Commonwealth of Independent States | 5 | 0.9% |
| Oceania | 17 | 3.0% |
| Europe Other | 28 | 5.0% |
| Europe Union | 58 | 10.3% |
| North America | 343 | 60.9% |
| Caribbean Islands | 5 | 0.9% |
| Central America | 35 | 6.2% |
| South America | 23 | 4.1% |
| Totals | 563 | 100.0% |

Also because of the homogeneity of the respondents, the responses to most questions showed significant skewness and some showed kurtosis. Those items are marked as significant within in the detail in appendix H (page 168).

**Full research reliability**

Reliability was examined using Cronbach's Alpha as was done in the pilot study. The summary for each variable shown in figure 8 below and the detail by question is shown in appendix I (page 173). The reverse scored questions (T3, A3, U4, U5) showed poor reliability and were subsequently eliminated during purification.

Overall, Cronbach's Alpha suggests there is reliability in the survey. All variables had statistics above the .7 minimum value for both the "start" and "end" columns.

*Figure 8: Cronbach's Alpha results by variable for the full research*

| Variable | Start | | End | |
|---|---|---|---|---|
| | Questions | Cronbach's Alpha | Questions Remaining | Cronbach's Alpha |
| Technological Turbulence | 5 | .379. | 4 | .784 |
| Market Turbulence | 5 | .765 | 5 | .765 |
| Competitive Turbulence | 5 | .851 | 5 | .851 |
| Regulatory Turbulence | 5 | .762 | 5 | .762 |
| Foundational Customers | 4 | .866 | 4 | .866 |
| Supplier Participation | 4 | .884 | 4 | .884 |
| Agile Development | 4 | .061 | 3 | .724 |
| Early Feedback | 4 | .815 | 4 | .815 |
| Late Decision Making | 4 | .778 | 4 | .778 |
| Product Development Outcomes | 4 | .820 | 4 | .820 |
| Uncertainty | 5 | .495 | 3 | .880 |
| Equivocality | 5 | .889 | 5 | .889 |
| Totals | 54 | | 50 | |

## Full research purification

As was done in the pilot study, Corrected Item Total Correlation (CITC) was used for the purification analysis. Appendix I (page 173) shows the purification results by question. The reverse scored questions (T3, A3, U4, U5) showed an unfavorable result for CITC and for Cronbach's Alpha so those questions were eliminated before analyzing the data against the research model.

In total, the responses for fifty questions moved the to the factor analysis and hypothesis testing described in the next chapter.

# CHAPTER IV

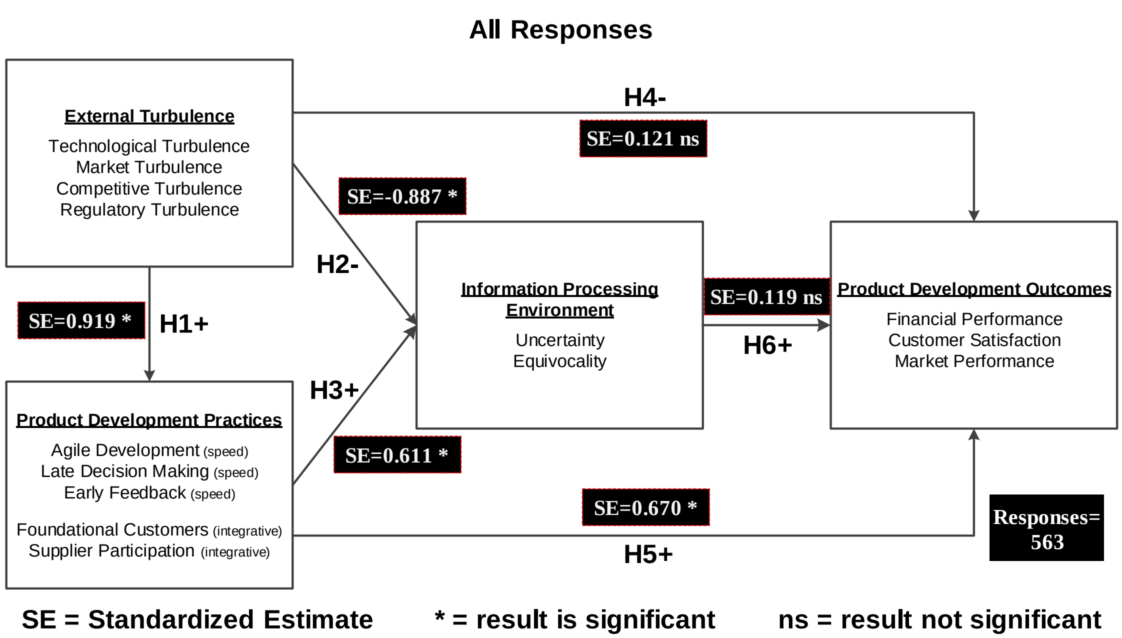
## Data Analysis and Results

The previous chapter explained the data collection process and data preparation. This chapter discusses the results of the factor analysis and the testing of the hypotheses. The analysis starts by considering the hypotheses using the results calculated from all the responses received. The subsequent sections consider various subsets of responses.

### Results from All Responses

In figure 9, the research model is shown with the Standardized Estimates calculated using all 563 responses.

*Figure 9: Path estimates using all responses*



The assumption of the research model is that in the presence of external turbulence, favorable product development outcomes result from your ability to process information and the product development practices you employ.

The crucial path, H6, hypothesized that less uncertainty and equivocality in the information processing environment would lead to better product development outcomes. H6 was not supported and the results for H6 shows the hypothesized positive relationship between the information processing environment and product development outcomes is not significant.

In the alternative, H5, was supported with a path estimate of 0.670. It shows that product development practices have a direct relationship to product development outcomes. That is, the use of integrative practices and process speed techniques has a positive relationship to achieving product development outcomes.

The relationship between external turbulence and product development outcomes, H4, was not supported. H4 hypothesized that that external turbulence upsets the overall new product development process and reduces the likelihood of product development success, however, H4 did not show a significant relationship between external turbulence and product development outcomes.

The remaining hypotheses related to external turbulence were supported. H1, with a path estimate of 0.898, shows the hypothesized positive relationship with product development practices. External turbulence generates a wave of change and a high volume of new information for the new product development team to process into new offerings.

H2, with a path estimate of -0.887, shows the hypothesized negative relationship that greater levels of external turbulence add uncertainty and equivocality to the information processing environment.

Conversely, H3, with a path estimate of 0.611 shows that the use of flexible new product development practices can offset the uncertainty and equivocality in the information processing environment.

## Model Fit Review

The model fit statistics for the "all responses" data set show a model that could be improved. The relevant model fit statistics are:

*Figure 10: Model fit statistics for the "all response" results*

| | |
|---|---|
| CMIN | 2975.839 |
| Degrees of Freedom | 1158 |
| CMIN/DF | 2.570 |
| RMR | 0.084 |
| GFI | 0.778 |
| NFI | 0.828 |
| RMSEA | 0.053 |

Additional model fit statistics are shown in appendix K (page 180).

## Demographics

Demographic information was collected from the respondents. Seven separate attributes were captured as shown in appendix J (page 177). In aggregate, the respondents were from a niche within the targeted healthcare group and the narrowness of that niche may help explain the results received.

Over 77% of the projects reported were completed after the Affordable Care Act ramp-up (see year of project completion) and over 60% of the leadership of those projects was primarily located in North America (see project leadership geography).

In addition, over 53% of the survey respondents held an IT / systems management role during the time of the project (see professional role). This research was intended to capture responses from a broad cross section of HIMSS membership. The IT / systems management role only makes up less than 20% of the global HIMSS membership (http://www.himss.org/annual-member-survey). Therefore, the responses were more concentrated around the IT point of view versus the other constituencies that participate in product development projects.

The projects reported were riskier than the average project performed by the firm by a 61% to 39% margin (see project risk) and most projects were larger projects by a 64% to 36% margin (see project size).

Turning to the research results by demographic group, figure 11 below shows the path estimates for selected demographic subsets. The standardized estimate for each hypothesis is shown, whether that result was significant, and the total number of responses collected for that demographic subset. The last column shows how many of the six hypotheses were supported in each demographic subset. The bottom row shows in how many of the demographic subsets each hypothesis was supported.

For example, only H1 was supported by all demographic subsets. See count of 13 on bottom row. That is, the hypothesized positive relationship be external turbulence and product development practices showed a strong direct relationship across all the respondent population subsets.

In the opposite direction, H4 was not supported. See count of 0 on bottom row. The hypothesized negative relationship between external turbulence and product development outcomes was not significant for any demographic subset.

*Figure 11: Path estimates for selected demographic groups*

| Demographic Group | Hypotheses | | | | | | Responses Collected | | Count of Supported Hypotheses |
|---|---|---|---|---|---|---|---|---|---|
| | H1 | H2 | H3 | H4 | H5 | H6 | | | |
| All Responses | 0.919 * | -0.887 * | 0.611 * | 0.121 ns | 0.670 * | 0.119 ns | 563 | 100% | 4 |
| **Project Leadership Geography** | | | | | | | | | |
| Just North America | 0.891 * | -0.874 * | 0.408 ns | 0.300 ns | 0.446 ns | 0.245 ns | 343 | 61% | 2 |
| All but North America | 0.935 * | -0.219 ns | 0.109 ns | 0.037 ns | 0.820 * | -0.106 ns | 220 | 39% | 2 |
| **Year of Project Completion** | | | | | | | | | |
| Finished During ACA | 0.898 * | -0.880 * | 0.344 ns | 0.720 ns | 0.798 * | 0.270 * | 438 | 78% | 4 |
| Finished Before ACA | 0.945 * | -0.123 ns | 0.477 ns | 0.531 ns | 0.189 ns | 0.001 ns | 125 | 22% | 1 |
| **Respondent Professional Role in Project** | | | | | | | | | |
| Non-IT Respondent | 0.938 * | -0.238 ns | 0.210 ns | 0.320 ns | 0.447 ns | 0.035 ns | 263 | 47% | 1 |
| IT Respondent | 0.889 * | -0.958 * | 0.361 ns | 0.148 ns | 0.696 * | 0.256 ns | 300 | 53% | 3 |
| **Project Risk** | | | | | | | | | |
| Safe Projects | 0.902 * | -0.805 ns | 0.702 ns | 0.161 ns | 0.195 ns | 0.201 ns | 219 | 39% | 1 |
| Risky Projects | 0.916 * | -0.729 ns | 0.429 ns | 0.148 ns | 0.694 * | 0.067 ns | 344 | 61% | 2 |
| **Firm's Employee Count** | | | | | | | | | |
| Large Firm | 0.927 * | -0.571 ns | 0.454 ns | 0.364 ns | 0.531 ns | 0.128 ns | 241 | 43% | 1 |
| Small Medium Firm | 0.932 * | -1.193 ns | 0.690 ns | -0.413 ns | 1.016 ns | 0.018 ns | 322 | 57% | 1 |
| **Project Size** | | | | | | | | | |
| Small Projects | 0.940 * | 0.919 * | -0.730 * | 0.298 ns | 0.430 ns | 0.022 ns | 201 | 36% | 3 |
| Large Projects | 0.890 * | -1.084 * | 0.704 * | 0.109 ns | 0.688 * | 0.201 ns | 362 | 64% | 4 |
| Count of Supported Hypotheses (max=13) | 13 | 6 | 3 | 0 | 6 | 1 | | | |

* = result is significant    ns = result not significant

In considering the firm's employee count, only the H1 hypothesis, the relationship between external turbulence and product development practices, was supported by either large or small firms. See last column =1 for the firm's employee count. All other hypotheses were not supported.

## <u>Results by Demographic Subset</u>

The next few sections will consider the results by selected demographic subsets in more detail and compare their results with all responses.

### Results by relative project size

The demographics collected included the relative project size for that business and asked was the project reported smaller, similar or larger relative to other projects executed by that firm? Figure 12 below shows the model by relative project size (large 64% vs small 36%).

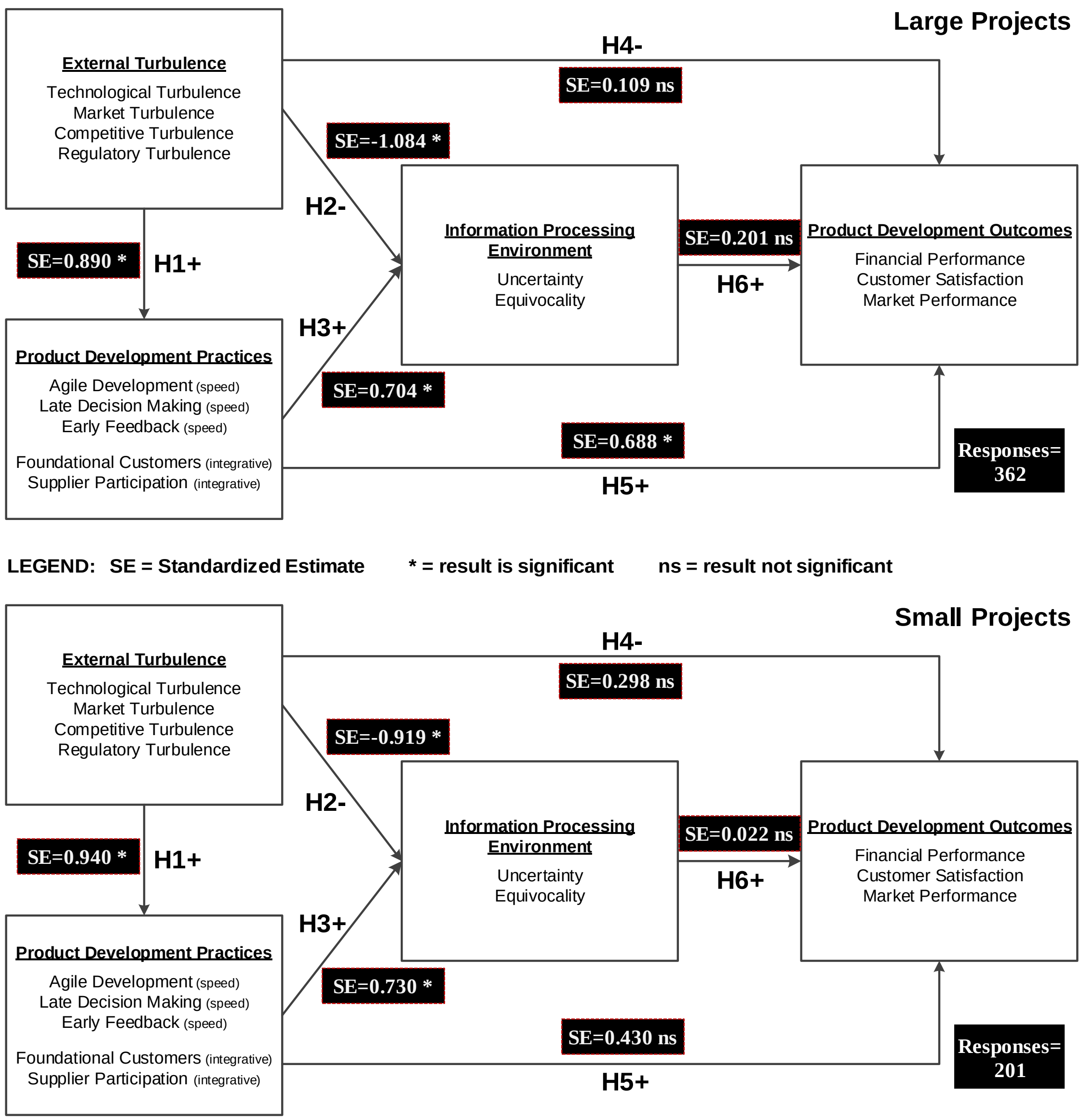
The path estimates for large projects showed similar results to the path estimates discussed above for all responses. As with the all responses, H5 was supported but only for large projects. With a path estimate of 0.688, H5 for large projects was supported and showed a strong direct relationship with product development outcomes.

H5 was not supported for small projects. That is, the product development practices employed for small projects did not show a significant relationship with product development outcomes.

As was found with the results from all responses, H4 and H6, the remaining paths that lead to product development outcomes, were not supported for both large and small projects.

The other paths in this subset, those related to the execution of the project, H1, H2 and H3, were supported for both large projects and for small projects. That result suggests that project teams across all project sizes use their product development practices to address external turbulence and information processing is required for the execution of the product development practices.

*Figure 12: Comparison of path estimates by relative project size—large versus small*

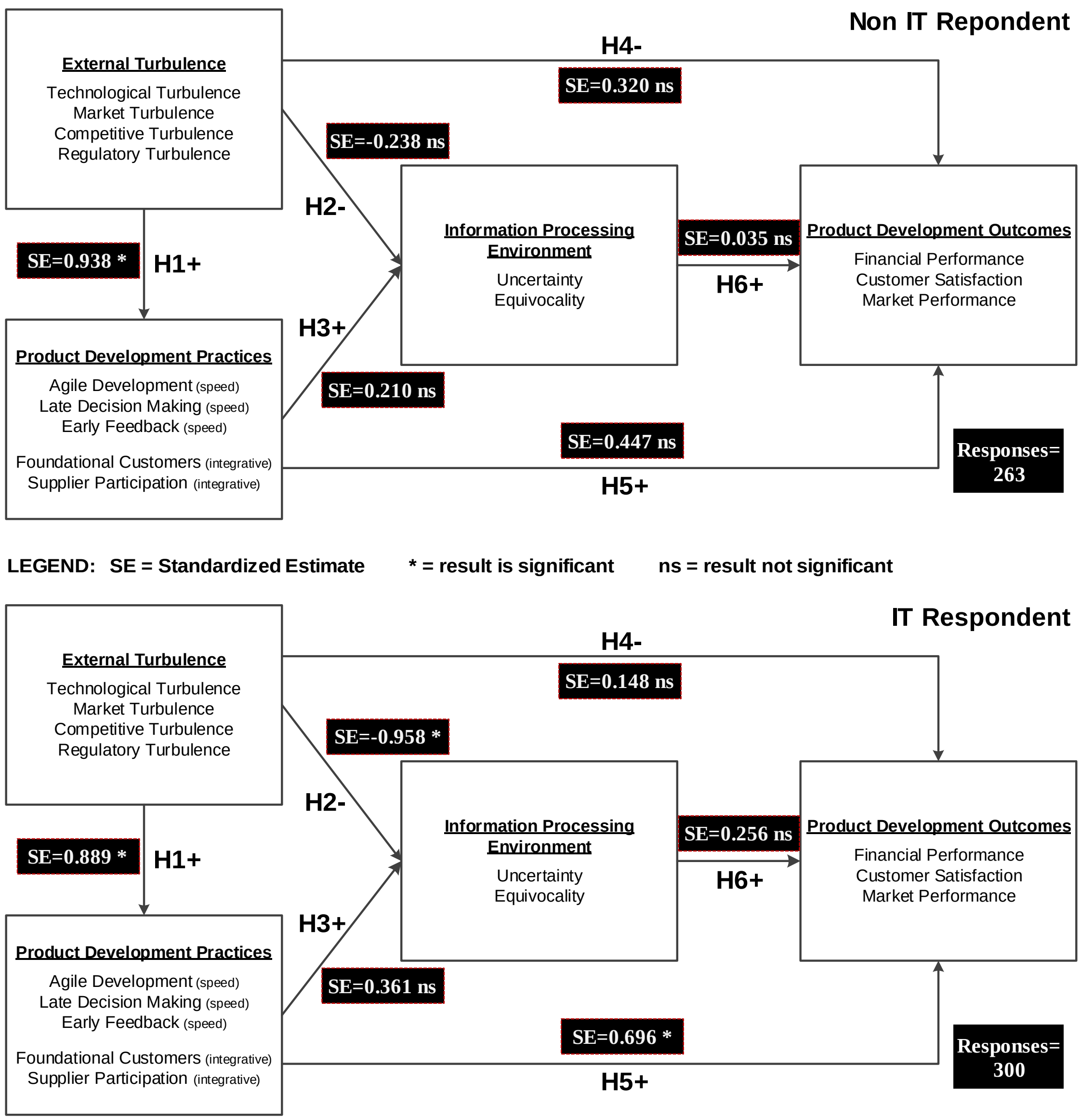



When contrasting project size, the results suggest that product development teams on large projects place more emphasis on the product development practices employed versus the teams on small projects. That outcome could reflect that teams on smaller projects require much less structure around their practices to achieve the desired project outcome while a more formal project organization is important on large projects.

## Results by professional role

The demographics collected included the respondents' professional role held within the product development project reported. With the large number of IT respondents, figure 13 shows a view of the research model looking at IT versus non-IT roles.

*Figure 13: Comparison of path estimates for IT and Non-IT professional roles*



As previously mentioned, the percentage of respondents holding an IT role was far greater in this research than the targeted general HIMSS membership population—53% of the respondents in this research versus less than 20% across all HIMSS members.

Noticeable differences are seen between the IT and non-IT roles and between both roles and the results from all responses.

For the non-IT role, H1 was the only hypothesis supported. External turbulence showed the hypothesized strong direct relationship with product development practices that is shown across all the demographic subsets. All other hypotheses for the non IT role were not supported. In particular, no hypothesized path to product development outcomes (H4, H5, H6) was significant.

This result may be related to the mix of roles in the respondent population. The design, engineering and product development roles only made up 21% of the respondents, see appendix J (page 177). If one assumes these roles are performing the information processing and making many of the decisions about product development practices that lead to the desired product development outcomes, then their under-sampling could explain the lack of significance in the hypotheses, (H4, H5, H6), intended to explain product development outcomes in all responses. In other words, the pool of respondents had an insufficient number of the decision makers using the information processed to make decisions about the practices to be employed to show a significant relationship to product development outcomes.

The IT role, showed results that were more consistent with the results of all responses. H1 and H2 were supported showing external turbulence had the hypothesized strong positive relationship with product development practices and the hypothesized strong negative relationship to information processing.

H5 was also supported and showed the hypothesized strong positive relationship between product development practices and outcomes.

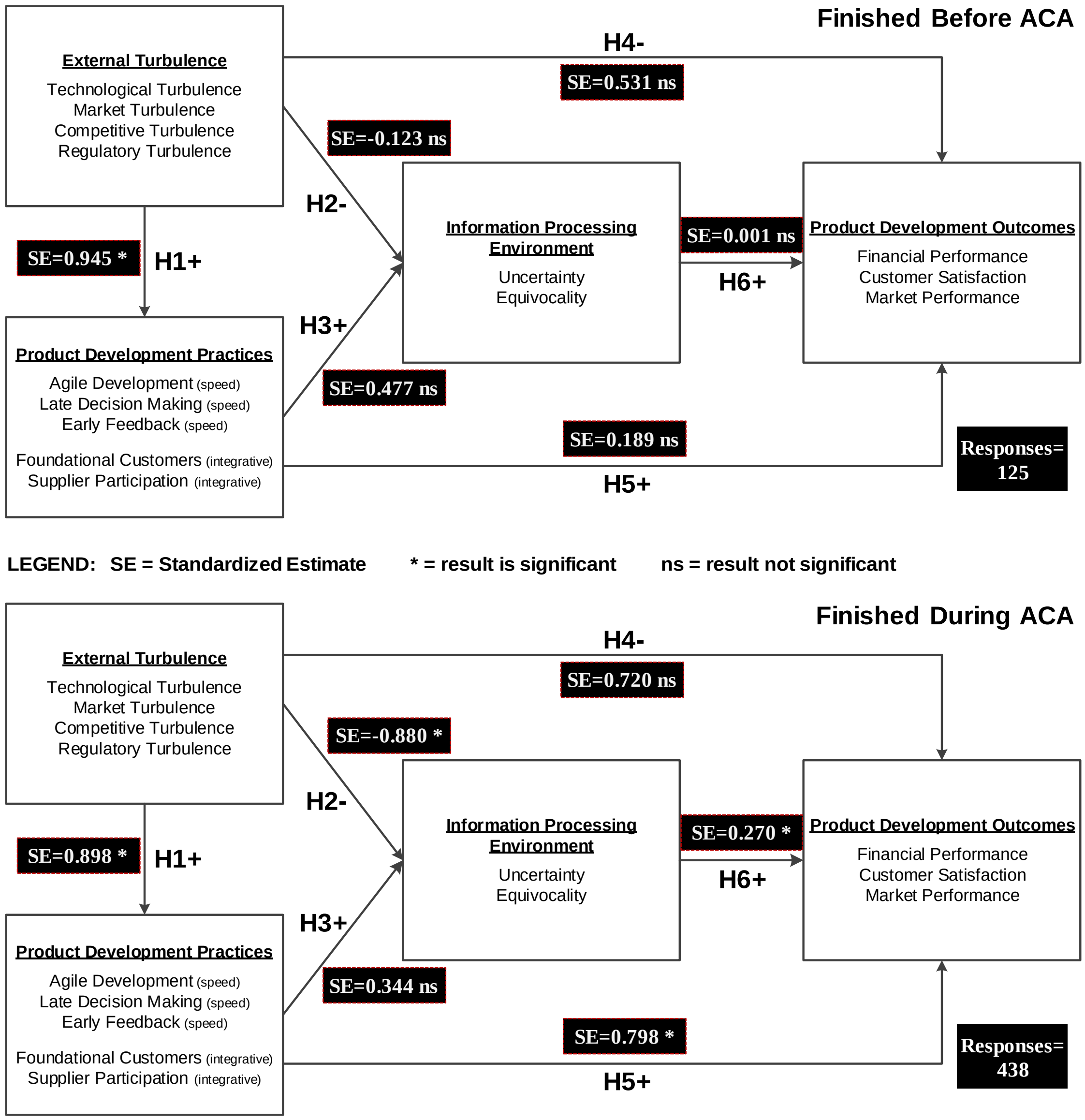
H3 was not supported. That is, the expected positive relationship between product development practices and information processing was not significant. The result suggests the IT role does not use information processing to resolve external turbulence. That outcome, may be inherent to the IT role. If one assumes that the IT role's greatest influence is at the end of the fuzzy end and possibly as a bridge between the fuzzy front end and constructions phases. It is possible that the activities involving information processing to resolve external turbulence occurred before the IT role had its greatest impact on the project.

**Results pre-post Affordable Care Act**

The demographic attributes collected included the year of project completion. That attribute was used to divide the responses into two groups with respect to pre / post Affordable Care Act. Projects completed in 2010 or prior were considered to have been completed before the Affordable Care Act ramped up and projects completed after 2010 were considered to include the effects of the Affordable Care Act.

Figure 14 below shows a comparison of standardized estimates for projects completing before and after the ramp-up of the Affordable Care Act. The differences between the time periods show primarily in information processing.

*Figure 14: Comparison of path estimates pre-post Affordable Care Act*




Before the passage of the Affordable Care Act, H6 was not supported. The relationship between information processing and product development outcomes was not significant. For projects that included the effects of the Affordable Care Act ramp-up, the relationship between information processing and production development outcomes was the significant hypothesized positive relationship with a path estimate of 0.270. Furthermore, the support for H6 in this demographic subset is the only significant result for H6 across all the respondent subsets reviewed.

Additional support is provided by H2. For projects finished before the Affordable Care Act ramp-up, H2 was not significant suggesting external turbulence did not substantially disrupt information processing. H2 was supported for projects finished during the Affordable Care Act ramp-up and showed the strong positive direct relationship with a path estimate of -0.880.

What made projects successful? Product development practices did not have a significant impact on product development outcomes before the Affordable Care Act's passage but had a strong positive relationship with product development outcomes after the act's passage. (H5 standardized estimate = not significant before and 0.798 after).

It seems that the healthcare market was quiet and consistent before the passage of the Affordable Care Act. Some new turbulent event would erupt, and a product development project would be executed to address the turbulence.

With the Affordable Care Act ramp-up, there was a wave of change and a high volume of new information generated by external turbulence. Those organizations that were successful used their information processing capabilities, H6, to address the changes, H2. Their information processing capability combined with integrative and flexible product development practices, H5, to generate positive new product development outcomes.

The next chapter summarizes the results and identifies conclusions, limitations and suggested direction for future research.

# CHAPTER V

## Summary and Conclusions

This chapter summarizes the results, presents implications, identifies limitations and suggests areas for future research.

### Discussion of Findings

The gap in the literature this research attempted to address involved the interrelationship of three variables, external turbulence, product development practices and information processing and how that interrelationship leads to desired new product development outcomes. The next few sections considers each variable and whether this research added to its understanding.

### Discussion of External Turbulence

In the literature review, the antecedents to new product development success had a bias towards stable markets. Little consideration was given to the effect of external turbulence on the fuzzy front-end activities that were considered successful in the "stable markets" research. This research was testing the idea that the path to desired product development outcomes is affected by external turbulence.

The results did not find the direct relationship expected. In fact, the direct relationship of external turbulence disrupting product development outcomes was the only hypothesized relationship that was not supported for any of the demographic subsets considered.

The finding is counter-intuitive to the abundance of business stories about disruption by external forces around markets, competition, new technologies and regulation.  The effect of external turbulence seems readily observable so what is actually occurring?  The discussion of new product development practices may help explain.

**Discussion of New Product Development Practices**

In the literature, product development practices had traditionally been the more structured and formal fuzzy front-end activities. The project was executed as a series of sequential process steps and varying from that sequence was to invite product failure. With the effects of external turbulence roiling certain markets, the introduction of flexible product development practices was considered, but only as a trade-off between product cost and quality in certain situations.

This research considered flexible product development practices as the solution to countering the effects of external turbulence and the results supported that conclusion. First, external turbulence showed the hypothesized positive direct relationship to the use of flexible new product development practices.  It was the most consistent result across all the demographic subsets considered.  Second, product development practices showed the direct positive relationship to product development outcomes.

These two findings taken together suggest a repeatable path to achieve desired new product development outcomes.  When external turbulence disrupts a product initiative, it is the application of flexible new product development practices that counters the turbulence and delivers the desired product development outcomes.

This finding described were illuminated by the view of projects completed before and after the ramp-up in the Affordable Care Act. Organizations that were successful in dealing with the external turbulence generated by the ramp-up of the Affordable Care Act did so using their product development practices to generate the desired product development outcomes. Of all the demographic subsets considered, the projects completed during the ramp-up of the Affordable Care Act showed the strongest path from external turbulence to product development practices to product development outcomes.

**Discussion of Information Processing**

The research expected that the product team's ability to process information was a crucial factor. Product development teams would use their information processing to makes sense of the volumes of new information generated by external turbulence and correspondingly develop the plan to counteract. Information processing was described using the Daft and Lengel (1986) definition and measured using their constructs of uncertainty and equivocality. It was hypothesized that information processing would have a direct and positive relationship on product development outcomes.

The results for information processing were not conclusive. The relationship between both external turbulence and product development practices to information processing showed the hypothesized relationships. External turbulence disrupted information processing with a wave of new information and the team's ability to process that information by using new product development practices was necessary to achieve desired product development outcomes.

The relationship of information processing to product development outcomes was less clear. It only showed the hypothesize relationship on the subset of projects completed during the ramp-up to the Affordable Care Act. While that subset likely experienced the strongest external turbulence of any group of product development projects reported, it is still noteworthy that the hypothesized relationship was not seen across more projects.

The mix of respondents may be a possible reason why information processing did not show the hypothesized behavior. The design, engineering and product development roles were likely significantly underrepresented in the respondent population. Those roles are the constituents on the product development team that are processing information and using that insight to make decisions.

## Implications

The research confirmed only some of the hypothesized relationships of achieving the product development outcomes desired from understanding the level of external turbulence, the product development practices to employ and the information processing needed.

The major implication from this study is the need by product development teams to consider external turbulence as a factor in all product plans. Where is turbulence originating now or what could be new sources of turbulence during the product lifecycle?

It is not clear from literature and from this research that all product teams do so. The management of turbulence needs to be come as standard as the management of customer requirements. It is likely that the wave of change and overload of new information from turbulent events will only increase thereby increasing the risk that unexpected events will nullify product plans while the project is in-flight.

The second item of importance is the consideration of varying product development practices employed to the situation. Rather than a tried and true repeatable check list of steps, product development practices should be selected and configured for each situation and the external environment encountered. Beyond the traditional steps to finalize requirements, calculate costs and develop release plans, the product development practices must now gather the information needed to counteract the external turbulent events.

Third, the organization of information processing should become a required competence on all product teams. As previously stated, product teams will have a limited capacity to gather information. It may be limited by the technical solutions available, by the competence of team members and the willingness of those members to collaborate. For a product development project to be successful, those individuals must converge on a similar interpretation of the information that successfully counteracts external turbulence.

Finally, with the accessibility of machine learning to sort through large amounts of information and help define the product, it is likely that the ability to process information will become an even more important tool for product teams to use in differentiating their offering in the market.

**Limitations and Areas for Future Research.**

The research had many limitations that could limit the broad application of the results across other products, geographies and product development processes. The future research suggested can overcome many of those limitations

**Product limitations**

The target respondents for this research were HIMSS members. Consequently, the types of projects reported were related to healthcare and mostly involved tangible goods such as medical devices, clinical equipment and healthcare applications. While that limitation offered a consistent population on which to draw contrasts in this research, there are many other product areas where the contrasts in how product teams address external turbulence could deliver much additional insight.

Potential targets include products contrasted by the type of buyer—consumer vs industry vs government. A similar contrast of interest is industry from aerospace to transportation.

Products with different characteristics for product lifecycle length and product price point may have completely different approaches to addressing the effects of external turbulence. For example, when price points are low and product lifecycle is short, the reaction to external turbulence may be to abandon the current offering and move to the next "big thing". If that outcome is correct, then product development processes and information processing may have little impact on the outcomes for those offerings.

The physical nature of the products such as manufactured goods vs applications like machine learning may have product development teams that approach the challenges of external turbulence differently. Machine learning is an interesting area to contrast against product development teams creating manufactured goods. First, the machine learning industry is in its early stages and external turbulence is likely high. Therefore, considering how product teams address constantly high external turbulence versus more stable external environments that may be found in the production of physical goods can provide useful information.

Of significant interest is how product development teams creating machine learning offerings address information processing. Machine learning technology is intended to make sense of large volumes of new and potentially confusing information. Product teams creating machine learning offerings are likely to be the early adopters of machine learning in product development. Does machine learning applied to information processing in product development improve project outcomes?

**Geographic limitations**

In this research, over sixty percent of the projects reported reflected the point of view of a North American product leadership team. Product leadership teams located in other geographies may respond differently to external turbulence. Investigating those cross-cultural nuances could provide additional insight. For example, a study using the full range leadership framework developed by Avolio and Bass (1999) or Hofstede's model of culture (Hofstede & McCrae, 2004) could identify which cultural patterns are more effective in dealing with external turbulence and, within those cultures, how different traits perform.

**Process limitations**

The product development processes considered in this research are those often used in the development of software applications, services and less complex manufactured products. Other product categories such as platform products, defense systems and chemicals may utilize a different menu of product development processes and those processes may have a different proficiency at counteracting the effects of external turbulence.

In addition, whether a healthcare product requires governmental approval or not, it is likely that the weight of regulation and the burden of potential litigation affects many decisions. Product development processes employed may be significantly different in other industries that are less regulated. More free-wheeling industries may resolve the challenges of external turbulence quite differently. How other processes utilize information and address external turbulence is an area worth further exploration.

**Constituent limitations**

The respondents for this research were heavily weighted towards the IT / systems management role (53%) when IT / systems management is only 20% of the target population. The survey questions are asking for the respondents' opinions and feelings about the environment and the processes employed. Responses by other product development team constituencies such as marketing, design, engineering, compliance and others may be quite different. Therefore, research that uses a more balanced respondent group where all constituencies are proportionally reflected may provide useful contrasts.

**Measurement limitations**

One potential reason the results did not show a significant positive relationship between information processing and product development outcomes may be the formation of those questions. The concepts of uncertainty and equivocality used to define the effectiveness of information processing may not be immediately understood in the short time respondents spent completing a survey. Therefore, improving the measurement of information processing within product development teams may yield different results.

Future research is crucial because new product development teams must overcome the increasing level of turbulence in their external environment to create the outcomes their organizations desire. Positive outcomes for new products are essential to succeeding in the global economy and to creating the wealth needed for a better society.

# APPENDICES

# APPENDIX A

# RESPONDENT SCREENING QUESTIONS

# Appendix A: Respondent Screening Questions

Potential respondents were screened with several questions shown below to verify they met the desired demographic. To enter the survey, respondents had to answer YES to questions one through four and to select any answer but "Other" for question five.

| # | Question Text |
|---|---|
| Q1: | I am a member of or am aware of HIMSS (Healthcare Information and Management Systems Society) *[yes / no]* |
| Q2: | I participated in a product development project that applied technology to healthcare *[yes / no]* |
| Q3: | The product development project completed within the past ten years *[yes / no]* |
| Q4: | I was involved in that product development project for most of its existence *[yes / no]* |
| Q5: | During the project timeframe, I primarily held a role in the area of:<br>*[bracketed number is survey system answer code]*<br>*Marketing / Sales / Channels [1]*<br>*Product Management [2]*<br>*Design [3]*<br>*Engineering / Development / QA [4]*<br>*General and Financial Management [7]*<br>*Regulatory / Compliance [5]*<br>*Research / Professor / Educator [8]*<br>*Clinical Management [9]*<br>*Government / Public Servant [10]*<br>*IT / Systems Management [11]*<br>*Other [6]* |

# APPENDIX B

## STRUCTURED INTERVIEW QUESTION SCRIPT

Appendix B: Structured Interview Question Script continued

EXTERNAL SOURCES OF TURBULENCE

VARIABLE: Technological Turbulence

Variable Definition

Technological turbulence refers to the rate of technological change.

Main Question

— For this project, how rapidly are the enabling technologies changing?

CLARIFICATION: Enabling technologies are those technologies in related, unrelated or loosely related domains that supply crucial capabilities to the products you create. For example, sensor technologies are crucial to firms building lab equipment that perform PCR clinical testing.

Supplemental Questions

1. For this project, is the rate of technological change increasing or decreasing?
2. For this project, what is the manner in which the enabling technologies change?
3. For this project, have there been any recent industry breakthroughs?

Closing Question

— For this project, if enabling technologies had significant changes, what tactics were used to counteract their impact?

Rating Question

— For this project and using a scale of one to seven, how rapidly are the enabling technologies changing? One is no change observed and seven is fast changing.

Appendix B: Structured Interview Question Script continued

EXTERNAL SOURCES OF TURBULENCE-CONTINUED

VARIABLE: Market Turbulence

Variable Definition

Market turbulence is the rate of change in customer preferences.

Main Question

— For this project, how rapidly are the customer preferences changing?

Supplemental Questions

1. For this project, are customers more interested in the low cost or product differentiation and is that interest changing?
2. For this project, if customer preferences are changing then what do you perceive as the source of that change?
3. For this project, how are customers communicating certainty in their preferences?

Closing Question

— If the rate of change in customer preferences was not insignificant then what tactics were used to counteract their impact?

Rating Question

— For this project and using a scale of one to seven, how rapidly are the customer preferences changing? One is no change observed and seven is fast changing.

Appendix B: Structured Interview Question Script continued

EXTERNAL SOURCES OF TURBULENCE-CONTINUED

VARIABLE: Competitive Turbulence

Variable Definition

Competitive turbulence considers the ability of competitors to thwart your market actions (aka competitive intensity).

Main Question

— For this project, how would you describe the competitive turbulence?

CLARIFICATION: This question considers the magnitude of competitive turbulence. That is the effect that a competitor can have on your organization.

Supplemental Questions

1. For this project, how easily can your competitors match your activities?
2. For this project, what are your competitors' organizational factors that affect their ability to thwart your actions?
3. For this project, how do you generally compete, lowest cost or product differentiation?

Closing Question

— For this project, if competitive intensity was not insignificant then what tactics were used to counteract its impact?

Rating Question

— For this project and using a scale of one to seven, how strong is competitive turbulence? One is very weak and seven is very strong.

Appendix B: Structured Interview Question Script continued

EXTERNAL SOURCES OF TURBULENCE-CONTINUED

VARIABLE: Regulatory Turbulence

Variable Definition

Regulatory turbulence considers the effect of high regulatory fluctuation.

Main Question

— For this project, how sizeable was regulatory fluctuation?

Supplemental Questions

1. For this project, has the stringency of the regulations changed?
2. For this project, has the rigor of enforcement changed?
3. For this project, did you need to seek waivers from any regulation?
4. For this project, did a regulation require a change in the product design?

Closing Question

— For this project, if regulatory impact was other than insignificant, what tactics were used to counteract its impact?

Rating Question

— For this project and using a scale of one to seven, how sizeable was regulatory fluctuation? One is very small and seven is very large.

Appendix B: Structured Interview Question Script continued

EXTERNAL SOURCES OF TURBULENCE-CONTINUED

VARIABLE: Economic Turbulence

Variable Definition

Economic turbulence is instability in the rate of economic activity.

Main Question

— During this project, how would you describe the stability or instability in the rate of external economic activity?

Supplemental Questions

1. During this project, was the level of external economic activity different than in the time period just before the project kick-off?
2. For this project, would you describe the nature of the economic uncertainty as not knowing which of a number of alternatives would be the outcome for some relevant issue?
3. For this project, would you describe the nature of the economic uncertainty as haziness about future events of consequence?

Closing Question

— If the change in external economic activity was other than insignificant, what tactics were used to counteract its impact?

Rating Question

— For this project and using a scale of one to seven, how stable was the rate of external economic activity? One is very unstable and seven is very stable.

Appendix B: Structured Interview Question Script continued

INTERNAL PRODUCT DEVELOPMENT PRACTICES

VARIABLE: Agile Development

Variable Definition

Agile development is characterized by rapid development iterations to gain feedback combined with overlapping processes where the next iteration begins before the current iteration finishes.

Main Question

— For this project, was an agile methodology used to develop the product?

Supplemental Questions

1. For this project, how was the agile process applied?
2. For this project, how did the product design adapt to iteration feedback?
3. For this project, how did the agile method affect the product development process?
4. For this project, did the agile method incite chaos or inject order?

Closing Question

— For this project and if an agile methodology was used, what impact did the agile methodology have on the project outcome?

Rating Question

— For this project and using a using a scale of one to seven, how much did an agile methodology drive the product development process? One is none and seven is very much.

Appendix B: Structured Interview Question Script continued

INTERNAL PRODUCT DEVELOPMENT PRACTICES-CONTINUED

VARIABLE: Foundational Customers

Variable Definition

Foundational customers refer to one or more customer representatives who participate in the new product development process and in a manner that helps shape the requirements.

Main Question

— For this project, how were customers involved in the process?

Supplemental Questions

1. For this project, how much of the product requirements were provided by customers?
2. For this project, with whom on the project team did the customers interact?
3. For this project, what was the nature of the customer interaction?
4. For this project, at what stage of the project did the customer interaction occur?

Closing Question

— For this project and if customers were involved, what impact did their involvement have on the project outcome?

Rating Question

— For this project and using a scale of one to seven, how much were customers involved in the process? One is no involvement and seven is very significant involvement.

Appendix B: Structured Interview Question Script continued

INTERNAL PRODUCT DEVELOPMENT PRACTICES-CONTINUED

VARIABLE: Early Feedback

Variable Definition

Early feedback refers to regularly gathering feedback from multiple internal constituents at the earliest stages of the product development process.

Main Question

— For this project, what internal constituencies outside the product development organization were involved in providing feedback during the project's front end?

Supplemental Questions

1. For this project, how were the internal constituencies involved in shaping the discussion?
2. For this project, how early were the various internal constituencies engaged?
3. For this project how were the various internal constituencies involved in making the product decisions?

Closing Question

— For this project and if early feedback was sought from internal constituencies outside the product development organization, what impact did the feedback have on the project outcome?

Rating Question

— For this project and using a scale of one through seven, how much feedback was gathered from internal constituents outside the product development organization during the project's end? One is none and seven is very much.

Appendix B: Structured Interview Question Script continued

INTERNAL PRODUCT DEVELOPMENT PRACTICES-CONTINUED

VARIABLE: Late Decision Making

Variable Definition

Product concepts, capabilities and designs are not frozen until the last phases of the development process

Main Question

— For this project, when were the product requirements frozen?

Supplemental Questions

1. For this project, how were the product requirements finalized?
2. For this project, did the environment for this product change between the time the product requirements were frozen and the product reached the market?
3. For this project, was the lag problematic between finalizing product requirements and the product's release?

Closing Question

— For this project, what impact did the timing of the requirements freeze have on the project outcome?

Rating Question

— For this project and using a scale of one to seven, when were the product requirements frozen? One is very early and seven is very late.

Appendix B: Structured Interview Question Script continued

INTERNAL PRODUCT DEVELOPMENT PRACTICES-CONTINUED

VARIABLE: Supplier Involvement

Variable Definition

Supplier participation defines the role that suppliers play in the product development processes. It ranges from simply delivering parts based on a specification to substantial involvement in the design process.

Main Question

— For this project, how did suppliers participate in the product's design?

Supplemental Questions

1. For this project, in what stages of the product development process were suppliers involved?
2. For this project, with whom did the suppliers interact?
3. For this project, what was the context of those interactions?

Closing Question

— For this project, what impact did supplier participation in product design have on the project outcome?

Rating Question

— For this project and using a scale of one to seven, how much did suppliers participate in product's design? One is no participation and seven is very significant participation.

Appendix B: Structured Interview Question Script continued

INTERNAL PROJECT TASK ENVIRONMENT

VARIABLE: Uncertainty

Variable Definition

Uncertainty generally means the absence of information and, in the project context, the difference between the information required to address an issue and the information available.

Main Question

— For this project, how would describe the information uncertainty?

CLARIFICATION: Information uncertainty is the difference in the level of information needed by the team to the level of information available or surfaced during the project?

Supplemental Questions

1. For this project, was the initial information available sufficient?
2. For this project, was the team able to obtain the missing information?
3. For this project, what was the perceived accuracy of the information?

Closing Question

— For this project, if information uncertainty was a factor in this project then what tactics were used to counteract its impact?

Rating Question

— For this project and using a scale of one to seven, what was the level of information uncertainty in this project? One is none and seven is a large amount.

Appendix B: Structured Interview Question Script continued

INTERNAL PROJECT TASK ENVIRONMENT-CONTINUED

VARIABLE: Equivocality

Variable Definition

Equivocality is synonymous with ambiguity and, in the organizational context; means there are multiple conflicting interpretations of a situation.

Main Question

— For this project, how would you describe the level of ambiguity about the information considered during the project?

Follow-Up Questions

1. For this project, how much did the team agree on the information's interpretation?
2. For this project, what was the confidence level for the information?
3. How did information clarity unfold during the project?

Closing Question

— For this project, if information ambiguity was a factor in this project then what tactics were used to counteract its impact?

Rating Question

— For this project and using a scale of one to seven, what was the level of information ambiguity on this project? One is none and seven is a large amount.

Appendix B: Structured Interview Question Script continued

PRODUCT DEVELOPMENT OUTCOMES

VARIABLE: Financial Performance

Variable Definition

Financial performance is the degree to which the product exceeded or fell short of the expected profitability level

Main Question

— For this project, what was its financial performance in comparison to expectations?

Supplemental Questions

1. For this project, does the product development methodology include the setting of meaningful financial goals?
2. For this project, were meaningful financial goals set?
3. For this project, did development costs meet or exceed estimates?
4. For this project, did product costs meet or exceed estimates?
5. For this project, was the target profit achieved?

Rating Question

— For this project and using a scale of one to seven, what was its financial performance in comparison to expectations? One is did not match expectations and seven is perfectly matched expectations.

Appendix B: Structured Interview Question Script continued

PRODUCT DEVELOPMENT OUTCOMES-CONTINUED

VARIABLE: Market Performance

Variable Definition

Market performance is the extent to which the product exceeded or fell short of achieving market expectations.

Main Question

— For this project, what was the market performance compared to expectations?

Supplemental Questions

1. For this project, does the product development methodology include the setting of meaningful goals for market performance?
2. For this project, were meaningful goals for market performance set?
3. For this project, did it exceed or fall short on sales volume?
4. For this project, did it exceed or fall short on market share attained?
5. For this project, did it exceed or fall short on market timing?

Rating Question

— For this project and using a scale of one to seven, what was the market performance compared to expectations? One is the project did not match expectations and seven is the project perfectly matched expectations.

Appendix B: Structured Interview Question Script continued

PRODUCT DEVELOPMENT OUTCOMES-CONTINUED

VARIABLE: Customer Satisfaction

Variable Definition

Customer satisfaction is defined as the level of the purchaser's affective response (negative to positive) for the product

Main Question

— For this project, how would you rate the customer satisfaction it generated?

Supplemental Questions

1. For this project, what was its effect on customer loyalty?
2. For this project, what was its effect on generating follow-on sales?
3. For this project, what was its effect on brand recognition?
4. For this project, what was its effect on displacing competitors?

Rating Question

— For this project and using a scale of one to seven, how would you rate the customer satisfaction it generated? One is a very negative response and seven is very positive response.

Appendix B: Structured Interview Question Script continued

Closing Questions

1. How well did this set of variables match your product development environment?
2. Would you suggest the addition of any other variables?
3. What variables do you think are most important?

# APPENDIX C

# PILOT STUDY INVITATION EMAIL

# Appendix C: Pilot Study Invitation Email

FROM: *[tested @nsu.edu email and @mxwl-dissertation.com addresses]*

TO: *[email address of HIMSS participants]*

SUBJECT: Asking for your industry expertise

For my dissertation, I am surveying product management professionals involved in healthcare to explore the relationship between turbulence and new product development practices.

The link below leads to a survey asking questions about a single completed product development project of your choosing. It is intended to be quickly completed in the white space of your day.

http://mxwl-dissertation.com

Your answers will be kept confidential, no proprietary information is requested and any data reported will be anonymized and aggregated.

By participating, you will receive a full, but anonymized, copy of the results which you may find useful in your work. In addition, you will have helped contribute to the body of knowledge in product management. Your contact details came from information collected at HIMSS.

Thank you for helping with my dissertation research,

Michael Maxwell
DBA Student at Nova Southeastern University

# APPENDIX D

## PILOT STUDY DRAFT MEASURE QUESTION DISPOSITION

Appendix D: Pilot Study Draft Measure Question Disposition continued

| Code | Question | Use in Full Research |
|---|---|---|
| | Technological Turbulence | |
| T1 | The technology changed rapidly | USED-no change |
| T2 | Technological improvements provided big opportunities | USED-no change |
| T3 | Forecasting the state of technology five years forward was difficult | USED-no change |
| T4 | Technological breakthroughs led to new products | USED-no change |
| T5 | The modes of production and service change often | USED-no change |
| T6 | New technology was applied in this project | NOT used |
| T6 | New technology was applied in this project | NOT used |
| | Market Turbulence | |
| M1 | Customer product preferences were changing | USED-no change |
| M2 | Customer demand was difficult to forecast | USED-no change |
| M3 | Customer service and support expectations increased | NOT used |
| M4 | Customer preferences were difficult to forecast | USED-no change |
| M5 | Customer product evaluation cycles became more rigorous | NOT used |
| M6 | Customers reevaluated their product choices more frequently | NOT used |
| M7 | Customers were looking for new products | USED-no change |
| M8 | New customers bought our products and services | NOT used |
| M9 | New customer needs were often different from existing customer needs | USED-no change |
| | Competitive Turbulence | |
| C1 | Competition in our industry was cutthroat | USED-edited |
| C2 | Competitors readily matched out actions | USED-no change |
| C3 | Competitors had strong sales forces | NOT used |
| C4 | Competitors had strong distribution systems | NOT used |
| C5 | New competitors regularly entered our industry | USED-edited |
| C6 | New competitive occurred regularly | USED-edited |
| C7 | Promotion wars were common | NOT used |
| C8 | Price competition was a hallmark of our industry | NOT used |
| C9 | Market share shifted | USED-edited |

Appendix D: Pilot Study Draft Measure Question Disposition continued

| Code | Question | Use in Full Research |
|---|---|---|
| | Regulatory Turbulence | |
| R1 | Our industry had stringent regulations | USED-no change |
| R2 | Regulatory changes shaped our business | USED-no change |
| R3 | Regulations were uncertain | USED-no change |
| R4 | Regulatory schemes varied widely in different countries | NOT used |
| R5 | Regulations changed quickly | NOT used |
| R6 | Regulations changed during product development | NOT used |
| R7 | Shifts in regulatory structures occurred often | NOT used |
| R8 | Regulations were implemented with varying rigor | NOT used |
| R9 | Our home country regulations impede our ability compete in other countries | USED-edited |
| R10 | New markets had more stringent regulations than our home country | USED-no change |
| R11 | Local companies had a regulatory advantage in foreign markets | NOT used |
| | Foundational Customers (integrative practice) | |
| F1 | We chose some customers to be project team members | USED-edited |
| F2 | We met often with customers on the project team | NOT used |
| F3 | Customers on the project team influenced the product concept | USED-no change |
| F4 | Customers on the project team contributed to product specifications | USED-no change |
| F5 | Customers on the project team described their expected use of this product | USED-no change |
| F6 | Customers on the project team were assigned specific product development issues | NOT used |
| F7 | Customers on the project team affected the final product specifications | NOT used |
| | Supplier Participation (integrative practice) | |
| S1 | Supplier participation on the project team was significant | USED-edited |
| S2 | Supplier employees and project team members communicated directly | USED-edited |
| S3 | Suppliers designed components for us | NOT used |
| S4 | Suppliers were involved in the early stages of this project | USED-no change |
| S5 | Suppliers performed the full product engineering for some components | NOT used |
| S6 | We made use of supplier expertise in the development of this project | USED-no change |
| S7 | We asked our suppliers for their input on the design of components | NOT used |

Appendix D: Pilot Study Draft Measure Question Disposition continued

| Code | Question | Use in Full Research |
|---|---|---|
| | Agile Development (speed) | |
| A1 | We used rapid development iterations | USED-no change |
| A2 | We used overlapping design iterations | USED-no change |
| A3 | We welcomed changing requirements even late in the process | USED-edited |
| A4 | We gave continuous attention to technical excellence and good design | NOT used |
| A5 | We gave all constituents equal status in evaluating iterations | NOT used |
| A6 | We communicated using the richest means available | USED-no change |
| A7 | Requirements evolved based on team learning | NOT used |
| A8 | Requirements evolved based on changing needs | NOT used |
| A9 | Self-organizing teams completed the product requirements | NOT used |
| | Early Feedback (speed) | |
| E1 | We involved many internal constituencies in the product development | USED-edited |
| E2 | We requested early feedback from all constituencies | NOT used |
| E3 | We aligned project objectives and incentives across all teams | USED-no change |
| E4 | We collaborated with groups who were not previously known | NOT used |
| E5 | All constituencies had responsibility to improve the product | NOT used |
| E6 | Team members had many opportunities for interaction across all internal constituencies | USED-edited |
| E7 | Team members were encouraged to exchange opinions/ideas | USED-no change |
| | Late Decision Making (speed) | |
| L1 | We made decisions as late possible | NOT used |
| L2 | We monitored customers, competitors and markets for events requiring last minute design changes | NOT used |
| L3 | We developed multiple prototypes throughout the front end process | USED-edited |
| L4 | We leveraged knowledge gained from changes in the external environment | NOT used |
| L5 | We made design decisions as late as possible | USED-no change |
| L6 | We performed experiments involving customers throughout the product's development | USED-no change |
| L7 | We postponed product design freeze until the final iteration | USED-no change |

Appendix D: Pilot Study Draft Measure Question Disposition continued

| Code | Question | Use in Full Research |
|---|---|---|
| | Product Development Outcomes | |
| O1 | Sales relative to expectations | USED-no change |
| O2 | Profit margin relative to expectations | USED-no change |
| O3 | Return on assets relative to expectations | NOT used |
| O4 | Return on investment relative to expectations | NOT used |
| O5 | Customer satisfaction relative to expectations | USED-no change |
| O6 | Customer loyalty relative to expectations | NOT used |
| O7 | Customer growth relative to expectations | NOT used |
| O8 | Market growth relative to expectations | USED-edited |
| O9 | Time to market relative to expectations | NOT used |
| O10 | Brand development relative to expectations | NOT used |
| | Uncertainty | |
| U1 | The information needed for product development was inadequate for our purposes | NOT used |
| U2 | The information needed for product development was of uncertain usefulness | USED-no change |
| U3 | The information needed for product development was too vague to be very helpful | USED-no change |
| U4 | The information needed for product development was perceived as too inaccurate | USED-no change |
| U5 | The information needed for product development was incomplete for our needs | USED-edited |
| U6 | The information needed for product development did not exist | USED-no change |
| | Equivocality | |
| V1 | The information needed for product development was ambiguous | USED-no change |
| V2 | The information needed for product development had multiple interpretations | USED-no change |
| V3 | The information needed for product development was interpreted differently by team members | USED-no change |
| V4 | The information needed for product development had conflicting interpretations | USED-no change |
| V5 | The information needed for product development was confusing because of different interpretations | USED-no change |

# APPENDIX E

# PILOT STUDY DESCRIPTIVE STATISTICS

# Appendix E: Pilot Study Descriptive Statistics

| Code | Question | Descriptive Statistics (7-pt Likert scale) | | | | | Skewness | | | Kurtosis | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cases | Min | Max | Mean | σ | α | Statistic | Std. Error | α | Statistic | Std. Error |
| Technological Turbulence | | | | | | | | | | | | |
| T1 | The technology changed rapidly | 55 | 2 | 7 | 5.29 | 1.423 | SIG | -1.419 | 0.322 | SIG | 1.276 | 0.634 |
| T2 | Technological improvements provided big opportunities | 55 | 4 | 7 | 5.96 | 0.860 | | -0.473 | 0.322 | | -0.395 | 0.634 |
| T3 | Forecasting the state of technology five years forward was difficult | 55 | 2 | 7 | 5.80 | 1.890 | SIG | -1.376 | 0.322 | | 0.181 | 0.634 |
| T4 | Technological breakthroughs led to new products | 55 | 4 | 7 | 6.04 | 1.018 | | -0.403 | 0.322 | SIG | -1.346 | 0.634 |
| T5 | The modes of production and service change often | 55 | 3 | 7 | 5.49 | 1.169 | | -0.411 | 0.322 | | -0.420 | 0.634 |
| T6 | New technology was applied in this project | 55 | 2 | 7 | 5.76 | 0.962 | SIG | -1.056 | 0.322 | SIG | 2.972 | 0.634 |
| Market Turbulence | | | | | | | | | | | | |
| M1 | Customer product preferences were changing | 55 | 3 | 7 | 5.89 | 0.994 | SIG | -0.831 | 0.322 | | 0.296 | 0.634 |
| M2 | Customer demand was difficult to forecast | 55 | 2 | 7 | 5.15 | 1.580 | | -0.248 | 0.322 | SIG | -1.327 | 0.634 |
| M3 | Customer service and support expectations increased | 55 | 0 | 7 | 5.18 | 1.504 | SIG | -1.372 | 0.322 | SIG | 2.164 | 0.634 |
| M4 | Customer preferences were difficult to forecast | 55 | 2 | 7 | 5.45 | 1.274 | SIG | -0.926 | 0.322 | | 0.984 | 0.634 |
| M5 | Customer product evaluation cycles became more rigorous | 55 | 2 | 7 | 5.05 | 1.557 | | -0.369 | 0.322 | | -1.015 | 0.634 |
| M6 | Customers reevaluated their product choices more frequently | 55 | 1 | 7 | 4.71 | 1.571 | | -0.180 | 0.322 | | -0.922 | 0.634 |
| M7 | Customers were looking for new products | 55 | 4 | 7 | 5.95 | 1.061 | | -0.467 | 0.322 | | -1.127 | 0.634 |
| M8 | New customers bought our products and services | 55 | 4 | 7 | 5.65 | 0.821 | | -0.103 | 0.322 | | -0.446 | 0.634 |
| M9 | New customer needs were often different from existing customer needs | 55 | 1 | 7 | 5.22 | 1.462 | SIG | -0.837 | 0.322 | | 0.251 | 0.634 |

Skewness or kurtosis is significant when: absolute (statistic / standard error) > 1.96
σ = sigma = standard deviation / α = alpha = significance

# Appendix E: Pilot Study Descriptive Statistics continued

| Code | Question | Descriptive Statistics (7-pt Likert scale) | | | | | Skewness | | | Kurtosis | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cases | Min | Max | Mean | σ | α | Statistic | Std. Error | α | Statistic | Std. Error |
| Competitive Turbulence | | | | | | | | | | | | |
| C1 | Competition in our industry was cutthroat | 55 | 3 | 7 | 5.56 | 1.067 | | -0.362 | 0.322 | | -0.755 | 0.634 |
| C2 | Competitors readily matched out actions | 55 | 1 | 7 | 5.24 | 1.347 | SIG | -0.875 | 0.322 | | 0.860 | 0.634 |
| C3 | Competitors had strong sales forces | 55 | 3 | 7 | 5.40 | 1.099 | | 0.177 | 0.322 | | -0.925 | 0.634 |
| C4 | Competitors had strong distribution systems | 55 | 2 | 7 | 5.09 | 1.059 | | 0.007 | 0.322 | | 0.544 | 0.634 |
| C5 | New competitors regularly entered our industry | 55 | 1 | 7 | 5.47 | 1.501 | SIG | -1.172 | 0.322 | SIG | 1.464 | 0.634 |
| C6 | New competitive occurred regularly | 55 | 1 | 7 | 5.02 | 1.225 | SIG | -0.726 | 0.322 | | 1.039 | 0.634 |
| C7 | Promotion wars were common | 55 | 1 | 7 | 3.71 | 1.499 | | -0.404 | 0.322 | | -0.348 | 0.634 |
| C8 | Price competition was a hallmark of our industry | 55 | 1 | 6 | 4.38 | 1.209 | | -0.332 | 0.322 | | -0.123 | 0.634 |
| C9 | Market share shifted | 55 | 1 | 7 | 4.64 | 1.282 | | -0.480 | 0.322 | | -0.076 | 0.634 |
| Regulatory Turbulence | | | | | | | | | | | | |
| R1 | Our industry had stringent regulations | 55 | 1 | 7 | 5.58 | 1.802 | SIG | -1.152 | 0.322 | | 0.429 | 0.634 |
| R2 | Regulatory changes shaped our business | 55 | 1 | 7 | 5.31 | 1.609 | SIG | -1.303 | 0.322 | | 1.144 | 0.634 |
| R3 | Regulations were uncertain | 55 | 1 | 7 | 4.62 | 1.616 | SIG | -0.904 | 0.322 | | 0.243 | 0.634 |
| R4 | Regulatory schemes varied widely in different countries | 55 | 1 | 7 | 4.05 | 1.850 | | -0.356 | 0.322 | | -0.582 | 0.634 |
| R5 | Regulations changed quickly | 55 | 1 | 7 | 4.13 | 1.504 | | -0.462 | 0.322 | | 0.504 | 0.634 |
| R6 | Regulations changed during product development | 55 | 1 | 7 | 3.80 | 1.736 | | -0.341 | 0.322 | | -0.379 | 0.634 |
| R7 | Shifts in regulatory structures occurred often | 55 | 1 | 7 | 3.60 | 1.559 | | -0.574 | 0.322 | | -0.398 | 0.634 |
| R8 | Regulations were implemented with varying rigor | 55 | 1 | 7 | 4.60 | 1.594 | | -0.331 | 0.322 | | 0.125 | 0.634 |
| R9 | Our home country regulations impede our ability compete in other countries | 55 | 1 | 6 | 3.29 | 1.663 | | -0.233 | 0.322 | | -1.230 | 0.634 |
| R10 | New markets had more stringent regulations than our home country | 55 | 1 | 6 | 3.73 | 1.533 | SIG | -0.864 | 0.322 | | -0.412 | 0.634 |
| R11 | Local companies had a regulatory advantage in foreign markets | 55 | 1 | 7 | 4.07 | 1.585 | SIG | -0.876 | 0.322 | | 0.183 | 0.634 |

Skewness or kurtosis is significant when: absolute (statistic / standard error) > 1.96
σ = sigma = standard deviation / α = alpha = significance

# Appendix E: Pilot Study Descriptive Statistics continued

| Code | Question | Descriptive Statistics (7-pt Likert scale) | | | | | Skewness | | | Kurtosis | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cases | Min | Max | Mean | σ | α | Statistic | Std. Error | α | Statistic | Std. Error |
| Foundational Customers (integrative practice) | | | | | | | | | | | | |
| F1 | We chose some customers to be project team members | 55 | 1 | 7 | 5.15 | 1.446 | SIG | -1.141 | 0.322 | SIG | 1.718 | 0.634 |
| F2 | We met often with customers on the project team | 55 | 2 | 7 | 5.73 | 1.008 | SIG | -0.655 | 0.322 | SIG | 1.791 | 0.634 |
| F3 | Customers on the project team influenced the product concept | 55 | 2 | 7 | 5.76 | 1.105 | SIG | -1.133 | 0.322 | SIG | 1.263 | 0.634 |
| F4 | Customers on the project team contributed to product specifications | 55 | 1 | 7 | 5.45 | 1.463 | SIG | -1.213 | 0.322 | SIG | 1.614 | 0.634 |
| F5 | Customers on the project team described their expected use of this product | 55 | 1 | 7 | 5.71 | 1.423 | SIG | -1.582 | 0.322 | SIG | 2.812 | 0.634 |
| F6 | Customers on the project team were assigned specific product development issues | 55 | 1 | 7 | 4.67 | 1.806 | | -0.311 | 0.322 | | -0.996 | 0.634 |
| F7 | Customers on the project team affected the final product specifications | 55 | 3 | 7 | 5.87 | 1.090 | | -0.363 | 0.322 | | -0.908 | 0.634 |
| Supplier Participation (integrative practice) | | | | | | | | | | | | |
| S1 | Supplier participation on the project team was significant | 55 | 1 | 7 | 3.78 | 2.166 | | -0.094 | 0.322 | SIG | -1.328 | 0.634 |
| S2 | Supplier employees and project team members communicated directly | 55 | 1 | 7 | 3.67 | 2.135 | | 0.054 | 0.322 | | -1.240 | 0.634 |
| S3 | Suppliers designed components for us | 55 | 1 | 7 | 3.96 | 2.357 | | -0.052 | 0.322 | SIG | -1.473 | 0.634 |
| S4 | Suppliers were involved in the early stages of this project | 55 | 1 | 7 | 3.38 | 2.207 | | 0.169 | 0.322 | SIG | -1.496 | 0.634 |
| S5 | Suppliers performed the full product engineering for some components | 55 | 1 | 7 | 3.84 | 2.291 | | 0.065 | 0.322 | SIG | -1.326 | 0.634 |
| S6 | We made use of supplier expertise in the development of this project | 55 | 1 | 7 | 3.45 | 2.387 | | 0.410 | 0.322 | SIG | -1.341 | 0.634 |
| S7 | We asked our suppliers for their input on the design of components | 55 | 1 | 7 | 3.47 | 2.227 | | 0.189 | 0.322 | SIG | -1.354 | 0.634 |

Skewness or kurtosis is significant when: absolute (statistic / standard error) > 1.96
σ = sigma = standard deviation / α = alpha = significance

# Appendix E: Pilot Study Descriptive Statistics continued

| Code | Question | Descriptive Statistics (7-pt Likert scale) | | | | | Skewness | | | Kurtosis | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cases | Min | Max | Mean | σ | α | Statistic | Std. Error | α | Statistic | Std. Error |
| Agile Development (speed) | | | | | | | | | | | | |
| A1 | We used rapid development iterations | 55 | 2 | 7 | 6.25 | 0.947 | SIG | -2.169 | 0.322 | SIG | 6.976 | 0.634 |
| A2 | We used overlapping design iterations | 55 | 2 | 7 | 5.55 | 1.372 | SIG | -0.679 | 0.322 | | -0.517 | 0.634 |
| A3 | We welcomed changing requirements even late in the process | 55 | 2 | 7 | 5.56 | 1.302 | SIG | -0.902 | 0.322 | | 0.677 | 0.634 |
| A4 | We gave continuous attention to technical excellence and good design | 55 | 2 | 7 | 5.65 | 1.250 | SIG | -0.661 | 0.322 | | -0.357 | 0.634 |
| A5 | We gave all constituents equal status in evaluating iterations | 55 | 2 | 7 | 4.76 | 1.347 | | 0.214 | 0.322 | | -0.395 | 0.634 |
| A6 | We communicated using the richest means available | 55 | 2 | 7 | 4.85 | 1.224 | | -0.342 | 0.322 | | 0.195 | 0.634 |
| A7 | Requirements evolved based on team learning | 55 | 2 | 7 | 5.84 | 1.014 | SIG | -0.875 | 0.322 | SIG | 2.090 | 0.634 |
| A8 | Requirements evolved based on changing needs | 55 | 5 | 7 | 6.02 | 0.707 | | -0.026 | 0.322 | | -0.938 | 0.634 |
| A9 | Self-organizing teams completed the product requirements | 55 | 1 | 7 | 5.20 | 1.325 | SIG | -1.374 | 0.322 | SIG | 2.407 | 0.634 |
| Early Feedback (speed) | | | | | | | | | | | | |
| E1 | We involved many internal constituencies in the product development | 55 | 1 | 7 | 5.49 | 1.609 | SIG | -1.326 | 0.322 | SIG | 1.634 | 0.634 |
| E2 | We requested early feedback from all constituencies | 55 | 3 | 7 | 5.78 | 1.031 | SIG | -0.910 | 0.322 | | 0.532 | 0.634 |
| E3 | We aligned project objectives and incentives across all teams | 55 | 2 | 7 | 5.11 | 1.343 | | -0.444 | 0.322 | | -0.376 | 0.634 |
| E4 | We collaborated with groups who were not previously known | 55 | 2 | 7 | 5.35 | 1.350 | | -0.338 | 0.322 | | -0.574 | 0.634 |
| E5 | All constituencies had responsibility to improve the product | 55 | 2 | 7 | 5.11 | 1.257 | SIG | -0.735 | 0.322 | | 0.447 | 0.634 |
| E6 | Team members had many opportunities for interaction across all internal constituencies | 55 | 3 | 7 | 4.91 | 0.986 | | -0.293 | 0.322 | | -0.615 | 0.634 |
| E7 | Team members were encouraged to exchange opinions/ideas | 55 | 3 | 7 | 5.80 | 0.989 | | -0.415 | 0.322 | | -0.284 | 0.634 |

Skewness or kurtosis is significant when: absolute (statistic / standard error) > 1.96
σ = sigma = standard deviation / α = alpha = significance

Appendix E: Pilot Study Descriptive Statistics continued

| Code | Question | Descriptive Statistics (7-pt Likert scale) | | | | | Skewness | | | Kurtosis | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cases | Min | Max | Mean | σ | α | Statistic | Std. Error | α | Statistic | Std. Error |
| Late Decision Making (speed) | | | | | | | | | | | | |
| L1 | We made decisions as late possible | 55 | 1 | 7 | 4.76 | 1.170 | SIG | -0.958 | 0.322 | | 1.072 | 0.634 |
| L2 | We monitored customers, competitors and markets for events requiring last minute design changes | 55 | 3 | 7 | 5.11 | 1.083 | | 0.411 | 0.322 | | -0.473 | 0.634 |
| L3 | We developed multiple prototypes throughout the front end process | 55 | 2 | 7 | 5.44 | 1.475 | | -0.481 | 0.322 | | -0.762 | 0.634 |
| L4 | We leveraged knowledge gained from changes in the external environment | 55 | 2 | 7 | 5.87 | 1.090 | | -0.630 | 0.322 | | 0.896 | 0.634 |
| L5 | We made design decisions as late as possible | 55 | 0 | 7 | 4.91 | 1.494 | SIG | -0.807 | 0.322 | | 0.880 | 0.634 |
| L6 | We performed experiments involving customers throughout the product's development | 55 | 2 | 7 | 5.42 | 1.066 | SIG | -0.920 | 0.322 | | 0.766 | 0.634 |
| L7 | We postponed product design freeze until the final iteration | 55 | 1 | 7 | 5.00 | 1.453 | SIG | -0.827 | 0.322 | | 0.141 | 0.634 |
| Product Development Outcomes | | | | | | | | | | | | |
| O1 | Sales relative to expectations | 55 | 1 | 7 | 3.82 | 0.964 | | 0.122 | 0.322 | SIG | 3.108 | 0.634 |
| O2 | Profit margin relative to expectations | 55 | 1 | 7 | 3.84 | 1.167 | SIG | 0.839 | 0.322 | SIG | 1.922 | 0.634 |
| O3 | Return on assets relative to expectations | 55 | 0 | 7 | 3.65 | 1.250 | | -0.130 | 0.322 | | 1.189 | 0.634 |
| O4 | Return on investment relative to expectations | 55 | 1 | 6 | 3.60 | 0.974 | | -0.230 | 0.322 | | 0.780 | 0.634 |
| O5 | Customer satisfaction relative to expectations | 55 | 1 | 7 | 4.69 | 1.034 | | -0.275 | 0.322 | SIG | 2.867 | 0.634 |
| O6 | Customer loyalty relative to expectations | 55 | 1 | 7 | 4.82 | 1.073 | | -0.183 | 0.322 | SIG | 2.367 | 0.634 |
| O7 | Customer growth relative to expectations | 55 | 1 | 7 | 4.36 | 0.969 | | 0.085 | 0.322 | SIG | 2.993 | 0.634 |
| O8 | Market growth relative to expectations | 55 | 1 | 7 | 4.29 | 0.994 | | -0.037 | 0.322 | SIG | 1.846 | 0.634 |
| O9 | Time to market relative to expectations | 55 | 2 | 7 | 3.85 | 0.989 | SIG | 0.898 | 0.322 | | 0.751 | 0.634 |
| O10 | Brand development relative to expectations | 55 | 1 | 7 | 4.36 | 1.161 | | 0.123 | 0.322 | | 0.189 | 0.634 |

Skewness or kurtosis is significant when: absolute (statistic / standard error) > 1.96
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# Appendix E: Pilot Study Descriptive Statistics continued

| Code | Question | Descriptive Statistics (7-pt Likert scale) | | | | | Skewness | | | Kurtosis | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cases | Min | Max | Mean | σ | α | Statistic | Std. Error | α | Statistic | Std. Error |
| Uncertainty | | | | | | | | | | | | |
| U1 | The information needed for product development was inadequate for our purposes | 55 | 1 | 7 | 4.22 | 1.739 | | -0.393 | 0.322 | | -1.119 | 0.634 |
| U2 | The information needed for product development was of uncertain usefulness | 55 | 1 | 6 | 4.04 | 1.414 | | -0.352 | 0.322 | | -1.026 | 0.634 |
| U3 | The information needed for product development was too vague to be very helpful | 55 | 1 | 6 | 3.78 | 1.301 | | -0.049 | 0.322 | | -1.072 | 0.634 |
| U4 | The information needed for product development was perceived as too inaccurate | 55 | 1 | 6 | 3.71 | 1.397 | | -0.386 | 0.322 | | -0.997 | 0.634 |
| U5 | The information needed for product development was incomplete for our needs | 55 | 1 | 7 | 3.98 | 1.705 | | -0.413 | 0.322 | | -1.193 | 0.634 |
| U6 | The information needed for product development did not exist | 55 | 1 | 6 | 3.53 | 1.980 | | -0.242 | 0.322 | SIG | -1.585 | 0.634 |
| Equivocality | | | | | | | | | | | | |
| V1 | The information needed for product development was ambiguous | 55 | 1 | 7 | 3.93 | 1.730 | | -0.307 | 0.322 | | -1.123 | 0.634 |
| V2 | The information needed for product development had multiple interpretations | 55 | 1 | 7 | 4.49 | 1.632 | SIG | -0.873 | 0.322 | | -0.484 | 0.634 |
| V3 | The information needed for product development was interpreted differently by team members | 55 | 1 | 7 | 4.35 | 1.818 | | -0.250 | 0.322 | | -0.884 | 0.634 |
| V4 | The information needed for product development had conflicting interpretations | 55 | 2 | 7 | 4.25 | 1.493 | | -0.247 | 0.322 | | -0.775 | 0.634 |
| V5 | The information needed for product development was confusing because of different interpretations | 55 | 2 | 7 | 4.24 | 1.551 | | -0.411 | 0.322 | SIG | -1.298 | 0.634 |

Skewness or kurtosis is significant when: absolute (statistic / standard error) > 1.96
σ = sigma = standard deviation / α = alpha = significance

# APPENDIX F

# PILOT STUDY RELIABILITY AND PURIFICATION STATISTICS

# Appendix F: Pilot Study Reliability and Purification Statistics

| Code | Question | Corrected Item-Total Correlation | | Cronbach's Alpha | |
|---|---|---|---|---|---|
| | | Start | End | Start | End |
| Technological Turbulence | | | | | |
| T1 | The technology changed rapidly | 0.549 | 0.509 | 0.580 | 0.598 |
| T2 | Technological improvements provided big opportunities | 0.443 | 0.420 | 0.636 | 0.652 |
| T3 | Forecasting the state of technology five years forward was difficult | 0.401 | 0.457 | 0.669 | 0.656 |
| T4 | Technological breakthroughs led to new products | 0.428 | 0.440 | 0.633 | 0.638 |
| T5 | The modes of production and service change often | 0.506 | 0.482 | 0.604 | 0.617 |
| T6 | New technology was applied in this project | 0.235 | DEL | 0.683 | DEL |
| Market Turbulence | | | | | |
| M1 | Customer product preferences were changing | 0.435 | 0.419 | 0.755 | 0.757 |
| M2 | Customer demand was difficult to forecast | 0.434 | 0.445 | 0.756 | 0.755 |
| M3 | Customer service and support expectations increased | 0.354 | 0.404 | 0.765 | 0.759 |
| M4 | Customer preferences were difficult to forecast | 0.389 | DEL | 0.760 | 0.767 |
| M5 | Customer product evaluation cycles became more rigorous | 0.557 | 0.546 | 0.733 | 0.734 |
| M6 | Customers reevaluated their product choices more frequently | 0.664 | 0.655 | 0.713 | 0.710 |
| M7 | Customers were looking for new products | 0.487 | 0.476 | 0.748 | 0.749 |
| M8 | New customers bought our products and services | 0.567 | 0.597 | 0.746 | 0.740 |
| M9 | New customer needs were often different from existing customer needs | 0.324 | DEL | 0.772 | DEL |
| Competitive Turbulence | | | | | |
| C1 | Competition in our industry was cutthroat | 0.667 | 0.609 | 0.797 | 0.839 |
| C2 | Competitors readily matched out actions | 0.673 | 0.700 | 0.792 | 0.822 |
| C3 | Competitors had strong sales forces | 0.470 | 0.557 | 0.817 | 0.848 |
| C4 | Competitors had strong distribution systems | 0.624 | 0.635 | 0.802 | 0.835 |
| C5 | New competitors regularly entered our industry | 0.279 | DEL | 0.844 | DEL |
| C6 | New competitive occurred regularly | 0.526 | DEL | 0.811 | DEL |
| C7 | Promotion wars were common | 0.428 | DEL | 0.825 | DEL |
| C8 | Price competition was a hallmark of our industry | 0.603 | 0.688 | 0.802 | 0.824 |
| C9 | Market share shifted | 0.650 | 0.690 | 0.796 | 0.824 |

Appendix F: Pilot Study Reliability Statistics continued

| Code | Question | Corrected Item-Total Correlation | | Cronbach's Alpha | |
|---|---|---|---|---|---|
| | | Start | End | Start | End |
| Regulatory Turbulence | | | | | |
| R1 | Our industry had stringent regulations | 0.542 | DEL | 0.787 | DEL |
| R2 | Regulatory changes shaped our business | 0.570 | DEL | 0.785 | DEL |
| R3 | Regulations were uncertain | 0.681 | 0.820 | 0.774 | 0.917 |
| R4 | Regulatory schemes varied widely in different countries | 0.322 | DEL | 0.811 | DEL |
| R5 | Regulations changed quickly | 0.619 | 0.827 | 0.781 | 0.916 |
| R6 | Regulations changed during product development | 0.579 | 0.881 | 0.783 | 0.905 |
| R7 | Shifts in regulatory structures occurred often | 0.695 | 0.836 | 0.773 | 0.914 |
| R8 | Regulations were implemented with varying rigor | 0.484 | 0.746 | 0.793 | 0.931 |
| R9 | Our home country regulations impede our ability compete in other countries | 0.474 | DEL | 0.794 | DEL |
| R10 | New markets had more stringent regulations than our home country | 0.166 | DEL | 0.822 | DEL |
| R11 | Local companies had a regulatory advantage in foreign markets | 0.123 | DEL | 0.826 | DEL |
| Foundational Customers (integrative practice) | | | | | |
| F1 | We chose some customers to be project team members | 0.519 | 0.556 | 0.869 | 0.871 |
| F2 | We met often with customers on the project team | 0.462 | DEL | 0.873 | DEL |
| F3 | Customers on the project team influenced the product concept | 0.805 | 0.801 | 0.836 | 0.837 |
| F4 | Customers on the project team contributed to product specifications | 0.808 | 0.805 | 0.828 | 0.827 |
| F5 | Customers on the project team described their expected use of this product | 0.624 | 0.650 | 0.855 | 0.855 |
| F6 | Customers on the project team were assigned specific product development issues | 0.705 | 0.670 | 0.848 | 0.859 |
| F7 | Customers on the project team affected the final product specifications | 0.708 | 0.678 | 0.847 | 0.854 |
| Supplier Participation (integrative practice) | | | | | |
| S1 | Supplier participation on the project team was significant | 0.949 | 0.976 | 0.979 | 0.949 |
| S2 | Supplier employees and project team members communicated directly | 0.974 | 0.969 | 0.978 | 0.974 |
| S3 | Suppliers designed components for us | 0.928 | 0.952 | 0.981 | 0.928 |
| S4 | Suppliers were involved in the early stages of this project | 0.932 | DEL | 0.980 | DEL |
| S5 | Suppliers performed the full product engineering for some components | 0.984 | 0.992 | 0.977 | 0.977 |
| S6 | We made use of supplier expertise in the development of this project | 0.855 | DEL | 0.986 | DEL |
| S7 | We asked our suppliers for their input on the design of components | 0.937 | 0.903 | 0.980 | 0.990 |

# Appendix F: Pilot Study Reliability Statistics continued

| Code | Question | Corrected Item-Total Correlation | | Cronbach's Alpha | |
|---|---|---|---|---|---|
| | | Start | End | Start | End |
| | **Agile Development (speed)** | | | | |
| A1 | We used rapid development iterations | 0.533 | 0.553 | 0.866 | 0.868 |
| A2 | We used overlapping design iterations | 0.742 | 0.782 | 0.846 | 0.843 |
| A3 | We welcomed changing requirements even late in the process | 0.678 | 0.682 | 0.853 | 0.855 |
| A4 | We gave continuous attention to technical excellence and good design | 0.514 | 0.532 | 0.869 | 0.872 |
| A5 | We gave all constituents equal status in evaluating iterations | 0.676 | 0.694 | 0.853 | 0.854 |
| A6 | We communicated using the richest means available | 0.683 | 0.639 | 0.853 | 0.860 |
| A7 | Requirements evolved based on team learning | 0.683 | 0.644 | 0.854 | 0.860 |
| A8 | Requirements evolved based on changing needs | 0.661 | 0.642 | 0.862 | 0.866 |
| A9 | Self-organizing teams completed the product requirements | 0.452 | DEL | 0.875 | DEL |
| | **Early Feedback (speed)** | | | | |
| E1 | We involved many internal constituencies in the product development | 0.492 | 0.537 | 0.769 | 0.782 |
| E2 | We requested early feedback from all constituencies | 0.635 | 0.659 | 0.739 | 0.748 |
| E3 | We aligned project objectives and incentives across all teams | 0.705 | 0.635 | 0.715 | 0.746 |
| E4 | We collaborated with groups who were not previously known | 0.313 | DEL | 0.798 | DEL |
| E5 | All constituencies had responsibility to improve the product | 0.606 | 0.577 | 0.738 | 0.761 |
| E6 | Team members had many opportunities for interaction across all internal constituencies | 0.457 | 0.489 | 0.768 | 0.782 |
| E7 | Team members were encouraged to exchange opinions/ideas | 0.463 | 0.496 | 0.767 | 0.781 |
| | **Late Decision Making (speed)** | | | | |
| L1 | We made decisions as late possible | 0.637 | 0.637 | 0.889 | 0.889 |
| L2 | We monitored customers, competitors and markets for events requiring last minute design changes | 0.648 | 0.648 | 0.888 | 0.888 |
| L3 | We developed multiple prototypes throughout the front end process | 0.762 | 0.762 | 0.875 | 0.875 |
| L4 | We leveraged knowledge gained from changes in the external environment | 0.769 | 0.769 | 0.876 | 0.876 |
| L5 | We made design decisions as late as possible | 0.804 | 0.804 | 0.869 | 0.869 |
| L6 | We performed experiments involving customers throughout the product's development | 0.582 | 0.582 | 0.895 | 0.895 |
| L7 | We postponed product design freeze until the final iteration | 0.734 | 0.734 | 0.879 | 0.879 |

Appendix F: Pilot Study Reliability Statistics continued

| Code | Question | Corrected Item-Total Correlation | | Cronbach's Alpha | |
|---|---|---|---|---|---|
| | | Start | End | Start | End |
| Product Development Outcomes | | | | | |
| O1 | Sales relative to expectations | 0.702 | 0.678 | 0.818 | 0.844 |
| O2 | Profit margin relative to expectations | 0.352 | DEL | 0.851 | DEL |
| O3 | Return on assets relative to expectations | 0.712 | 0.660 | 0.815 | 0.846 |
| O4 | Return on investment relative to expectations | 0.587 | 0.587 | 0.828 | 0.855 |
| O5 | Customer satisfaction relative to expectations | 0.643 | 0.686 | 0.823 | 0.842 |
| O6 | Customer loyalty relative to expectations | 0.671 | 0.681 | 0.820 | 0.843 |
| O7 | Customer growth relative to expectations | 0.608 | 0.647 | 0.826 | 0.848 |
| O8 | Market growth relative to expectations | 0.536 | 0.550 | 0.832 | 0.860 |
| O9 | Time to market relative to expectations | 0.309 | DEL | 0.851 | DEL |
| O10 | Brand development relative to expectations | 0.385 | DEL | 0.848 | DEL |
| Uncertainty | | | | | |
| U1 | The information needed for product development was inadequate for our purposes | 0.793 | 0.793 | 0.938 | 0.938 |
| U2 | The information needed for product development was of uncertain usefulness | 0.890 | 0.890 | 0.927 | 0.927 |
| U3 | The information needed for product development was too vague to be very helpful | 0.850 | 0.850 | 0.933 | 0.933 |
| U4 | The information needed for product development was perceived as too inaccurate | 0.821 | 0.821 | 0.935 | 0.935 |
| U5 | The information needed for product development was incomplete for our needs | 0.890 | 0.890 | 0.925 | 0.925 |
| U6 | The information needed for product development did not exist | 0.816 | 0.816 | 0.939 | 0.939 |
| Equivocality | | | | | |
| V1 | The information needed for product development was ambiguous | 0.774 | 0.774 | 0.936 | 0.936 |
| V2 | The information needed for product development had multiple interpretations | 0.827 | 0.827 | 0.925 | 0.925 |
| V3 | The information needed for product development was interpreted differently by team members | 0.838 | 0.838 | 0.924 | 0.924 |
| V4 | The information needed for product development had conflicting interpretations | 0.937 | 0.937 | 0.908 | 0.908 |
| V5 | The information needed for product development was confusing because of different interpretations | 0.819 | 0.819 | 0.927 | 0.927 |

# APPENDIX G

# PILOT STUDY EXPLORATORY FACTOR ANALYSIS

# Appendix G: Pilot Study Exploratory Factor Analysis

| | Components | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| S5 | 0.96 | | | | | | | | | | | | | | |
| S2 | 0.96 | | | | | | | | | | | | | | |
| S7 | 0.93 | | | | | | | | | | | | | | |
| S1 | 0.93 | | | | | | | | | | | | | | |
| S4 | 0.93 | | | | | | | | | | | | | | |
| S3 | 0.92 | | | | | | | | | | | | | | |
| S6 | 0.87 | | | | | | | | | | | | | | |
| R6 | | 0.90 | | | | | | | | | | | | | |
| R7 | | 0.87 | | | | | | | | | | | | | |
| R3 | | 0.86 | | | | | | | | | | | | | |
| R5 | | 0.84 | | | | | | | | | | | | | |
| R8 | | 0.78 | | | | | | | | | | | | | |
| R2 | | 0.59 | | | | | | | | | | | | | |
| R1 | | 0.55 | | | | | | | | | | | | | |
| U5 | | | 0.92 | | | | | | | | | | | | |
| U2 | | | 0.91 | | | | | | | | | | | | |
| U3 | | | 0.88 | | | | | | | | | | | | |
| U6 | | | 0.87 | | | | | | | | | | | | |
| U4 | | | 0.84 | | | | | | | | | | | | |
| U1 | | | 0.84 | | | | | | | | | | | | |
| A2 | | | | 0.83 | | | | | | | | | | | |
| A8 | | | | 0.75 | | | | | | | | | | | |
| A7 | | | | 0.73 | | | | | | | | | | | |
| A6 | | | | 0.69 | | | | | | | | | | | |
| A5 | | | | 0.67 | | | | | | | | | | | |
| A3 | | | | 0.65 | | | | | | | | | | | |
| A9 | | | | 0.46 | | | | | | | | | | | |
| A1 | | | | 0.40 | | | | | | | | | | | |
| V4 | | | | | 0.92 | | | | | | | | | | |
| V3 | | | | | 0.89 | | | | | | | | | | |
| V2 | | | | | 0.86 | | | | | | | | | | |
| V5 | | | | | 0.84 | | | | | | | | | | |
| V1 | | | | | 0.82 | | | | | | | | | | |
| L7 | | | | | | 0.82 | | | | | | | | | |
| L4 | | | | | | 0.80 | | | | | | | | | |
| L5 | | | | | | 0.79 | | | | | | | | | |
| L3 | | | | | | 0.71 | | | | | | | | | |
| L1 | | | | | | 0.71 | | | | | | | | | |
| L6 | | | | 0.41 | | 0.58 | | | | | | | | | |
| L2 | | | | | | 0.52 | | | | | | | | | |

Appendix G: Pilot Study Exploratory Factor Analysis Continued

| | Components | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| F4 | | | | | | | 0.85 | | | | | | | | |
| F3 | | | | | | | 0.81 | | | | | | | | |
| F7 | | | | | | | 0.80 | | | | | | | | |
| F5 | | | | | | | 0.78 | | | | | | | | |
| F4 | | | | | | | 0.85 | | | | | | | | |
| F1 | | | | | | | 0.54 | | | | | | | | |
| F2 | | | | | | | 0.54 | | | | | | | | |
| O4 | | | | | | | | 0.90 | | | | | | | |
| O3 | | | | | | | | 0.84 | | | | | | | |
| O1 | | | | | | | | 0.79 | | | | | | | |
| O2 | | | | | | | | 0.77 | | | | | | | |
| R11 | | | | | | | | | 0.85 | | | | | | |
| R10 | | | | | | | | | 0.83 | | | | | | |
| R4 | | | | | | | | | 0.83 | | | | | | |
| R9 | | | | | | | | | 0.79 | | | | | | |
| C8 | | | | | | | | | | 0.80 | | | | | |
| C9 | | | | | | | | | | 0.77 | | | | | |
| C3 | | | | | | | | | | 0.68 | | | | | 0.47 |
| C4 | | | | | | | | | | 0.61 | | | | | |
| C2 | | | | | | | | | | 0.59 | | | | | |
| C1 | | | | | | | | | | 0.51 | | | | 0.46 | |
| O8 | | | | | | | | | | | 0.76 | | | | |
| O7 | | | | | | | | | | | 0.75 | | | | |
| O10 | | | | | | | | | | | 0.74 | | | | |
| O5 | | 0.41 | | | | | | | | | 0.59 | | | | |
| O6 | -0.48 | | | | | | | | | | 0.56 | | | | |
| E1 | | | | | | | | | | | | 0.83 | | | |
| E2 | | | | | | | | | | | | 0.71 | | | |
| E3 | | | | | | | | | | | | 0.55 | | | |
| M5 | | | | | | | | | | | | | 0.75 | | |
| M6 | | | | | | | | | | | | | 0.72 | | |
| C6 | | | | | | | | | | | | | | 0.86 | |
| C5 | | | | | | | | | | | | | | 0.74 | |
| T6 | | | | | | | | | | | | | | | 0.77 |
| A4 | | | | 0.45 | | | | | | | | | | | |
| E7 | | | | | | | | | | | | 0.44 | | | |

# APPENDIX H

# FULL RESEARCH DESCRIPTIVE STATISTICS

# Appendix H: Full Research Descriptive Statistics

| Code | Question | Descriptive Statistics (5-pt Likert scale) | | | | | Skewness | | | Kurtosis | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cases | Min | Max | Mean | σ | α | Statistic | Std. Error | α | Statistic | Std. Error |
| | Technological Turbulence | | | | | | | | | | | |
| T1 | The technology changed | 563 | 1 | 5 | 3.9 | 0.968 | SIG | -0.686 | 0.103 | | 0.214 | 0.206 |
| T2 | Technological improvements provided big opportunities | 563 | 1 | 5 | 4.0 | 0.919 | SIG | -0.716 | 0.103 | | 0.159 | 0.206 |
| T3 | Forecasting the state of technology five years forward was easy | 563 | 1 | 5 | 2.4 | 1.110 | SIG | 0.428 | 0.103 | SIG | -0.644 | 0.206 |
| T4 | Technological breakthroughs led to new products | 563 | 1 | 5 | 3.9 | 0.951 | SIG | -0.827 | 0.103 | SIG | 0.512 | 0.206 |
| T5 | The modes of production or services changed | 563 | 1 | 5 | 3.8 | 0.988 | SIG | -0.589 | 0.103 | | -0.043 | 0.206 |
| | Market Turbulence | | | | | | | | | | | |
| M1 | Customer preferences were changing | 563 | 1 | 5 | 3.9 | 0.943 | SIG | -0.663 | 0.103 | | 0.015 | 0.206 |
| M2 | Customer demand was difficult to forecast | 563 | 1 | 5 | 3.6 | 1.097 | SIG | -0.394 | 0.103 | SIG | -0.616 | 0.206 |
| M3 | Customer preferences were difficult to forecast | 563 | 1 | 5 | 3.6 | 1.127 | SIG | -0.427 | 0.103 | SIG | -0.611 | 0.206 |
| M4 | Customers were looking for new products | 563 | 1 | 5 | 3.9 | 0.950 | SIG | -0.752 | 0.103 | | 0.216 | 0.206 |
| M5 | New customer needs were different from existing customers | 563 | 1 | 5 | 3.8 | 1.008 | SIG | -0.527 | 0.103 | | -0.233 | 0.206 |
| | Competitive Turbulence | | | | | | | | | | | |
| C1 | Competition in our industry was intense | 563 | 1 | 5 | 3.8 | 0.943 | SIG | -0.498 | 0.103 | | -0.274 | 0.206 |
| C2 | Competitors readily matched our actions | 563 | 1 | 5 | 3.7 | 1.038 | SIG | -0.490 | 0.103 | SIG | -0.433 | 0.206 |
| C3 | New competitors entered our industry | 563 | 1 | 5 | 3.8 | 1.037 | SIG | -0.667 | 0.103 | | -0.045 | 0.206 |
| C4 | New competitive actions occurred regularly | 563 | 1 | 5 | 3.8 | 0.980 | SIG | -0.505 | 0.103 | | -0.192 | 0.206 |
| C5 | Competitor market shares rapidly changed | 563 | 1 | 5 | 3.7 | 1.028 | SIG | -0.429 | 0.103 | SIG | -0.511 | 0.206 |

Skewness or kurtosis is significant when: absolute (statistic / standard error) > 1.96

σ = sigma = standard deviation / α = alpha = significance

Hatched items were eliminated from further analysis due to reliability concerns

# Appendix H: Full Research Descriptive Statistics continued

| Code | Question | Descriptive Statistics (5-pt Likert scale) | | | | | Skewness | | | Kurtosis | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cases | Min | Max | Mean | σ | α | Statistic | Std. Error | α | Statistic | Std. Error |
| Regulatory Turbulence | | | | | | | | | | | | |
| R1 | Our industry had stringent regulations | 563 | 1 | 5 | 3.9 | 0.956 | SIG | -0.674 | 0.103 | | 0.163 | 0.206 |
| R2 | Regulatory changes shaped our business | 563 | 1 | 5 | 3.9 | 0.972 | SIG | -0.664 | 0.103 | | 0.059 | 0.206 |
| R3 | Regulations were uncertain | 563 | 1 | 5 | 3.4 | 1.204 | SIG | -0.465 | 0.103 | SIG | -0.676 | 0.206 |
| R4 | Home country regulations impeded our ability to compete in other countries | 563 | 1 | 5 | 3.4 | 1.227 | SIG | -0.504 | 0.103 | SIG | -0.605 | 0.206 |
| R5 | Other countries had more stringent regulations than our home country | 563 | 1 | 5 | 3.4 | 1.207 | SIG | -0.385 | 0.103 | SIG | -0.721 | 0.206 |
| Foundational Customers (integrative practice) | | | | | | | | | | | | |
| F1 | Customers served on the project team | 563 | 1 | 5 | 3.6 | 1.167 | SIG | -0.620 | 0.103 | SIG | -0.413 | 0.206 |
| F2 | Customers on the project team influenced the product concept | 563 | 1 | 5 | 3.6 | 1.034 | SIG | -0.610 | 0.103 | | -0.025 | 0.206 |
| F3 | Customers on the project team contributed to product specifications | 563 | 1 | 5 | 3.6 | 1.100 | SIG | -0.611 | 0.103 | | -0.242 | 0.206 |
| F4 | Customers on the project team described their expected use of this product | 563 | 1 | 5 | 3.7 | 1.083 | SIG | -0.679 | 0.103 | | -0.104 | 0.206 |
| Supplier Participation (integrative practice) | | | | | | | | | | | | |
| S1 | Suppliers participated on the project team | 563 | 1 | 5 | 3.6 | 1.155 | SIG | -0.629 | 0.103 | | -0.284 | 0.206 |
| S2 | Supplier employees and project team members communicated | 563 | 1 | 5 | 3.6 | 1.127 | SIG | -0.692 | 0.103 | | -0.142 | 0.206 |
| S3 | Suppliers were involved in the early stages of this project | 563 | 1 | 5 | 3.6 | 1.147 | SIG | -0.609 | 0.103 | | -0.269 | 0.206 |
| S4 | We made use of supplier expertise in the development of this project | 563 | 1 | 5 | 3.7 | 1.132 | SIG | -0.600 | 0.103 | | -0.383 | 0.206 |

Skewness or kurtosis is significant when: absolute (statistic / standard error) > 1.96
σ = sigma = standard deviation / α = alpha = significance
Hatched items were eliminated from further analysis due to reliability concerns

Appendix H: Full Research Descriptive Statistics continued

| Code | Question | Descriptive Statistics (5-pt Likert scale) | | | | | Skewness | | | Kurtosis | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cases | Min | Max | Mean | σ | α | Statistic | Std. Error | α | Statistic | Std. Error |
| | **Agile Development (speed)** | | | | | | | | | | | |
| A1 | We used rapid development iterations | 563 | 1 | 5 | 3.7 | 1.007 | SIG | -0.695 | 0.103 | | 0.101 | 0.206 |
| A2 | We used overlapping design iterations | 563 | 1 | 5 | 3.8 | 1.028 | SIG | -0.666 | 0.103 | | -0.065 | 0.206 |
| A3 | We refused changing requirements late in the product development process | 563 | 1 | 5 | 2.6 | 1.178 | SIG | 0.359 | 0.103 | SIG | -0.771 | 0.206 |
| A4 | We communicated using the richest media available | 563 | 1 | 5 | 3.7 | 0.994 | SIG | -0.560 | 0.103 | | -0.107 | 0.206 |
| | **Early Feedback (speed)** | | | | | | | | | | | |
| E1 | We involved internal stakeholders in the product development process | 563 | 1 | 5 | 3.8 | 1.015 | SIG | -0.682 | 0.103 | | -0.005 | 0.206 |
| E2 | Project objectives and incentives were aligned across all teams | 563 | 1 | 5 | 3.9 | 0.981 | SIG | -0.711 | 0.103 | | 0.215 | 0.206 |
| E3 | Team members had opportunities for interaction across all internal groups | 563 | 1 | 5 | 3.9 | 1.009 | SIG | -0.714 | 0.103 | | 0.096 | 0.206 |
| E4 | Team members were encouraged to exchange opinions/ideas | 563 | 1 | 5 | 4.0 | 0.954 | SIG | -0.744 | 0.103 | | 0.062 | 0.206 |
| | **Late Decision Making (speed)** | | | | | | | | | | | |
| L1 | Multiple prototypes were developed during the front-end process | 563 | 1 | 5 | 3.8 | 0.972 | SIG | -0.639 | 0.103 | | 0.069 | 0.206 |
| L2 | Design decisions were made as late as possible | 563 | 1 | 5 | 3.6 | 1.082 | SIG | -0.499 | 0.103 | SIG | -0.464 | 0.206 |
| L3 | Experiments were performed involving customers throughout the product's development | 563 | 1 | 5 | 3.8 | 1.002 | SIG | -0.651 | 0.103 | | -0.082 | 0.206 |
| L4 | Product design freeze was postponed until the final iteration | 563 | 1 | 5 | 3.6 | 1.101 | SIG | -0.518 | 0.103 | | -0.312 | 0.206 |

Skewness or kurtosis is significant when: absolute (statistic / standard error) > 1.96
σ = sigma = standard deviation / α = alpha = significance
Hatched items were eliminated from further analysis due to reliability concerns

# Appendix H: Full Research Descriptive Statistics continued

| Code | Question | Descriptive Statistics (5-pt Likert scale) | | | | | Skewness | | | Kurtosis | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cases | Min | Max | Mean | σ | α | Statistic | Std. Error | α | Statistic | Std. Error |
| Product Development Outcomes | | | | | | | | | | | | |
| O1 | Sales meet expectations | 563 | 1 | 5 | 4.0 | 0.945 | SIG | -0.825 | 0.103 | SIG | 0.604 | 0.206 |
| O2 | Profit margin meet expectations | 563 | 1 | 5 | 3.9 | 0.925 | SIG | -0.651 | 0.103 | | 0.214 | 0.206 |
| O3 | Customer satisfaction meet expectations | 563 | 1 | 5 | 4.1 | 0.866 | SIG | -0.851 | 0.103 | SIG | 0.408 | 0.206 |
| O4 | Market share meet expectations | 563 | 1 | 5 | 4.0 | 0.825 | SIG | -0.683 | 0.103 | SIG | 0.588 | 0.206 |
| Uncertainty | | | | | | | | | | | | |
| U1 | The information available was of uncertain usefulness | 563 | 1 | 5 | 2.7 | 1.289 | SIG | 0.286 | 0.103 | SIG | -1.026 | 0.206 |
| U2 | The information needed was too vague to be helpful | 563 | 1 | 5 | 2.9 | 1.290 | | 0.153 | 0.103 | SIG | -1.060 | 0.206 |
| U3 | The information available was perceived as too inaccurate | 563 | 1 | 5 | 2.9 | 1.329 | | 0.174 | 0.103 | SIG | -1.128 | 0.206 |
| U4 | The information available was considered complete for our needs | 563 | 1 | 5 | 3.7 | 0.985 | SIG | -0.719 | 0.103 | | 0.191 | 0.206 |
| U5 | The information needed for this project existed | 563 | 1 | 5 | 3.9 | 1.014 | SIG | -0.820 | 0.103 | | 0.382 | 0.206 |
| Equivocality | | | | | | | | | | | | |
| V1 | The information available was considered ambiguous | 563 | 1 | 5 | 2.6 | 1.288 | SIG | 0.308 | 0.103 | SIG | -0.990 | 0.206 |
| V2 | The information available had multiple interpretations | 563 | 1 | 5 | 2.5 | 1.092 | SIG | 0.401 | 0.103 | SIG | -0.472 | 0.206 |
| V3 | The information available was interpreted differently by team members | 563 | 1 | 5 | 2.5 | 1.148 | SIG | 0.408 | 0.103 | SIG | -0.556 | 0.206 |
| V4 | The information available had conflicting interpretations | 563 | 1 | 5 | 2.7 | 1.238 | SIG | 0.392 | 0.103 | SIG | -0.841 | 0.206 |
| V5 | The information needed was confusing because of different interpretations | 563 | 1 | 5 | 2.8 | 1.323 | SIG | 0.254 | 0.103 | SIG | -1.078 | 0.206 |

Skewness or kurtosis is significant when: absolute (statistic / standard error) > 1.96
σ = sigma = standard deviation / α = alpha = significance
Hatched items were eliminated from further analysis due to reliability concerns

# APPENDIX I

# FULL RESEARCH RELIABILITY AND PURIFICATION STATISTICS

# Appendix I: Full Research Reliability and Purification Statistics

| Code | Question | Corrected Item-Total Correlation | | Cronbach's Alpha | |
|---|---|---|---|---|---|
| | | Start | End | Start | End |
| | Technological Turbulence | | | | |
| T1 | The technology changed | 0.414 | 0.578 | 0.135 | 0.737 |
| T2 | Technological improvements provided big opportunities | 0.516 | 0.605 | 0.056 | 0.724 |
| T3 | Forecasting the state of technology five years forward was easy | -0.467 | | 0.784 | |
| T4 | Technological breakthroughs led to new products | 0.476 | 0.600 | 0.082 | 0.726 |
| T5 | The modes of production or services changed | 0.456 | 0.577 | 0.089 | 0.738 |
| | Market Turbulence | | | | |
| M1 | Customer preferences were changing | 0.497 | 0.497 | 0.736 | 0.736 |
| M2 | Customer demand was difficult to forecast | 0.563 | 0.563 | 0.713 | 0.713 |
| M3 | Customer preferences were difficult to forecast | 0.543 | 0.543 | 0.721 | 0.721 |
| M4 | Customers were looking for new products | 0.519 | 0.519 | 0.729 | 0.729 |
| M5 | New customer needs were different from existing customers | 0.557 | 0.557 | 0.715 | 0.715 |
| | Competitive Turbulence | | | | |
| C1 | Competition in our industry was intense | 0.613 | 0.613 | 0.832 | 0.832 |
| C2 | Competitors readily matched our actions | 0.645 | 0.645 | 0.825 | 0.825 |
| C3 | New competitors entered our industry | 0.707 | 0.707 | 0.808 | 0.808 |
| C4 | New competitive actions occurred regularly | 0.705 | 0.705 | 0.809 | 0.809 |
| C5 | Competitor market shares rapidly changed | 0.639 | 0.639 | 0.826 | 0.826 |
| | Regulatory Turbulence | | | | |
| R1 | Our industry had stringent regulations | 0.448 | 0.448 | 0.746 | 0.746 |
| R2 | Regulatory changes shaped our business | 0.488 | 0.488 | 0.734 | 0.734 |
| R3 | Regulations were uncertain | 0.593 | 0.593 | 0.696 | 0.696 |
| R4 | Home country regulations impeded our ability to compete in other countries | 0.612 | 0.612 | 0.688 | 0.688 |
| R5 | Other countries had more stringent regulations than our home country | 0.524 | 0.524 | 0.723 | 0.723 |
| | Foundational Customers (integrative practice) | | | | |
| F1 | Customers served on the project team | 0.681 | 0.681 | 0.845 | 0.845 |
| F2 | Customers on the project team influenced the product concept | 0.724 | 0.724 | 0.827 | 0.827 |
| F3 | Customers on the project team contributed to product specifications | 0.759 | 0.759 | 0.811 | 0.811 |
| F4 | Customers on the project team described their expected use of this product | 0.706 | 0.706 | 0.833 | 0.833 |

Hatched items were eliminated from further analysis due to reliability concerns

# Appendix I: Full Research Reliability and Purification Statistics continued

| Code | Question | Corrected Item-Total Correlation | | Cronbach's Alpha | |
|---|---|---|---|---|---|
| | | Start | End | Start | End |
| Supplier Participation (integrative practice) | | | | | |
| S1 | Suppliers participated on the project team | 0.722 | 0.722 | 0.861 | 0.861 |
| S2 | Supplier employees and project team members communicated | 0.774 | 0.774 | 0.841 | 0.841 |
| S3 | Suppliers were involved in the early stages of this project | 0.775 | 0.775 | 0.841 | 0.841 |
| S4 | We made use of supplier expertise in the development of this project | 0.721 | 0.721 | 0.861 | 0.861 |
| Agile Development (speed) | | | | | |
| A1 | We used rapid development iterations | 0.402 | 0.575 | -0.652 | 0.599 |
| A2 | We used overlapping design iterations | 0.256 | 0.557 | -0.361 | 0.620 |
| A3 | We refused changing requirements late in the product development process | -0.461 | | 0.724 | |
| A4 | We communicated using the richest media available | 0.286 | 0.503 | -0.400 | 0.684 |
| Early Feedback (speed) | | | | | |
| E1 | We involved internal stakeholders in the product development process | 0.561 | 0.561 | 0.803 | 0.803 |
| E2 | Project objectives and incentives were aligned across all teams | 0.682 | 0.682 | 0.746 | 0.746 |
| E3 | Team members had opportunities for interaction across all internal groups | 0.676 | 0.676 | 0.748 | 0.748 |
| E4 | Team members were encouraged to exchange opinions/ideas | 0.624 | 0.624 | 0.773 | 0.773 |
| Late Decision Making (speed) | | | | | |
| L1 | Multiple prototypes were developed during the front-end process | 0.554 | 0.554 | 0.738 | 0.738 |
| L2 | Design decisions were made as late as possible | 0.606 | 0.606 | 0.711 | 0.711 |
| L3 | Experiments were performed involving customers throughout the product's development | 0.602 | 0.602 | 0.714 | 0.714 |
| L4 | Product design freeze was postponed until the final iteration | 0.568 | 0.568 | 0.732 | 0.732 |
| Product Development Outcomes | | | | | |
| O1 | Sales meet expectations | 0.667 | 0.667 | 0.762 | 0.762 |
| O2 | Profit margin meet expectations | 0.641 | 0.641 | 0.775 | 0.775 |
| O3 | Customer satisfaction meet expectations | 0.605 | 0.605 | 0.791 | 0.791 |
| O4 | Market share meet expectations | 0.663 | 0.663 | 0.767 | 0.767 |

Hatched items were eliminated from further analysis due to reliability concerns

# Appendix I: Full Research Reliability and Purification Statistics continued

| e | Question | Corrected Item-Total Correlation | | Cronbach's Alpha | |
|---|---|---|---|---|---|
| | | Start | End | Start | End |
| | Uncertainty | | | | |
| U1 | The information available was of uncertain usefulness | 0.469 | 0.733 | 0.285 | 0.859 |
| U2 | The information needed was too vague to be helpful | 0.625 | 0.790 | 0.147 | 0.809 |
| U3 | The information available was perceived as too inaccurate | 0.569 | 0.779 | 0.190 | 0.819 |
| U4 | The information available was considered complete for our needs | -0.156 | | 0.644 | |
| U5 | The information needed for this project existed | -0.082 | | 0.616 | |
| | Equivocality | | | | |
| V1 | The information available was considered ambiguous | 0.718 | 0.718 | 0.869 | 0.869 |
| V2 | The information available had multiple interpretations | 0.695 | 0.695 | 0.874 | 0.874 |
| V3 | The information available was interpreted differently by team members | 0.743 | 0.743 | 0.863 | 0.863 |
| V4 | The information available had conflicting interpretations | 0.776 | 0.776 | 0.855 | 0.855 |
| V5 | The information needed was confusing because of different interpretations | 0.735 | 0.735 | 0.866 | 0.866 |

Hatched items were eliminated from further analysis due to reliability concerns

# APPENDIX J

# FULL RESEARCH DEMOGRAPHIC RESULTS

# Appendix J: Full Research Demographic Results

The following tables show the demographic data collected with all the responses:

D1-Year of project completion

| Code | Description | Responses | Percent |
|---|---|---|---|
| 1 | 2014 to 2017 | 329 | 58.4% |
| 2 | 2011 to 2013 | 109 | 19.4% |
| 3 | 2008 to 2010 | 56 | 9.9% |
| 4 | 2005 to 2007 | 49 | 8.7% |
| 5 | Older | 20 | 3.6% |
| Totals | | 563 | 100.0% |

D2-Professional Role

| Code | Description | Responses | Percent |
|---|---|---|---|
| 1 | Design, Engineering, Product Development | 117 | 20.8% |
| 2 | Marketing / Sales | 34 | 6.0% |
| 3 | Clinical Management | 51 | 9.1% |
| 4 | IT / Systems Management | 300 | 53.3% |
| 5 | General and Financial Management | 24 | 4.3% |
| 6 | Researcher, Professor, Educator | 30 | 5.3% |
| 7 | Government, Public Servant | 6 | 1.1% |
| 8 | Other | 1 | 0.2% |
| Totals | | 563 | 100.1% |

D3-Project Leadership Geography

| Code | Description | Responses | Percent |
|---|---|---|---|
| 1 | Africa Central | 11 | 2.0% |
| 2 | Africa Eastern | 3 | 0.5% |
| 3 | Africa Northern | 2 | 0.4% |
| 4 | Africa Southern | 3 | 0.5% |
| 5 | Africa Western | 0 | 0.0% |
| 6 | Asia Eastern | 2 | 0.4% |
| 7 | Asia Southeast | 12 | 2.1% |
| 8 | Asia Southern | 10 | 1.8% |
| 9 | Asia Western | 6 | 1.1% |
| 10 | Commonwealth of Independent States (CIS) | 5 | 0.9% |
| 11 | Oceania | 17 | 3.0% |
| 12 | Europe Other | 28 | 5.0% |
| 13 | Europe Union | 58 | 10.3% |
| 14 | North America | 343 | 60.9% |
| 15 | Caribbean Islands | 5 | 0.9% |
| 16 | Central America | 35 | 6.2% |
| 17 | South America | 23 | 4.1% |
| Totals | | 563 | 100.1% |

Appendix J: Full Research Demographic Results continued

D4-Employee Count

| Code | Description | Responses | Percent |
|---|---|---|---|
| 1 | Below 2,000 | 123 | 21.8% |
| 2 | 2,000 to 4,999 | 199 | 35.3% |
| 3 | 5,000 to 7,999 | 76 | 13.5% |
| 4 | 8,000 to 10,999 | 62 | 11.0% |
| 5 | 11,000 to 13,999 | 56 | 9.9% |
| 6 | 14,000 to 16,999 | 47 | 8.3% |
| Totals | | 563 | 99.8% |

D5-Incremental or Innovative

| Code | Description | Responses | Percent |
|---|---|---|---|
| 1 | Incremental Update | 15 | 2.7% |
| 2 | | 28 | 5.0% |
| 3 | Balanced Release | 126 | 22.4% |
| 4 | | 230 | 40.9% |
| 5 | Innovative New Product | 164 | 29.1% |
| Totals | | 563 | 100.1% |

D6-Project Size

| Code | Description | Responses | Percent |
|---|---|---|---|
| 1 | Smaller | 6 | 1.1% |
| 2 | | 21 | 3.7% |
| 3 | Similar | 174 | 30.9% |
| 4 | | 229 | 40.7% |
| 5 | Larger | 133 | 23.6% |
| Totals | | 563 | 100.0% |

D7-Project Risk

| Code | Description | Responses | Percent |
|---|---|---|---|
| 1 | Smaller | 9 | 1.6% |
| 2 | | 34 | 6.0% |
| 3 | Similar | 176 | 31.3% |
| 4 | | 233 | 41.4% |
| 5 | Larger | 111 | 19.7% |
| Totals | | 563 | 100.0% |

# APPENDIX K

# MODEL FIT STATISTICS

# Appendix K: Model Fit Statistics

The following tables show the model fits statistics for the all response results:

CMIN

| Model | NPAR | CMIN | DF | P | CMIN/DF |
|---|---|---|---|---|---|
| Default model | 117 | 2975.839 | 1158 | .000 | 2.570 |
| Saturated model | 1275 | .000 | 0 | | |
| Independence model | 50 | 17261.788 | 1225 | .000 | 14.091 |

RMR, GFI

| Model | RMR | GFI | AGFI | PGFI |
|---|---|---|---|---|
| Default model | .084 | .778 | .756 | .707 |
| Saturated model | .000 | 1.000 | | |
| Independence model | .386 | .143 | .108 | .138 |

Baseline Comparisons

| Model | NFI Delta1 | RFI rho1 | IFI Delta2 | TLI rho2 | CFI |
|---|---|---|---|---|---|
| Default model | .828 | .818 | .887 | .880 | .887 |
| Saturated model | 1.000 | | 1.000 | | 1.000 |
| Independence model | .000 | .000 | .000 | .000 | .000 |

Parsimony-Adjusted Measures

| Model | PRATIO | PNFI | PCFI |
|---|---|---|---|
| Default model | .945 | .782 | .838 |
| Saturated model | .000 | .000 | .000 |
| Independence model | 1.000 | .000 | .000 |

NCP

| Model | NCP | LO 90 | HI 90 |
|---|---|---|---|
| Default model | 1817.839 | 1660.538 | 1982.747 |
| Saturated model | .000 | .000 | .000 |
| Independence model | 16036.788 | 15615.535 | 16464.477 |

FMIN

| Model | FMIN | F0 | LO 90 | HI 90 |
|---|---|---|---|---|
| Default model | 5.295 | 3.235 | 2.955 | 3.528 |
| Saturated model | .000 | .000 | .000 | .000 |
| Independence model | 30.715 | 28.535 | 27.786 | 29.296 |

# Appendix K: Model Fit Statistics

RMSEA

| Model | RMSEA | LO 90 | HI 90 | PCLOSE |
|---|---|---|---|---|
| Default model | .053 | .051 | .055 | .023 |
| Independence model | .153 | .151 | .155 | .000 |

AIC

| Model | AIC | BCC | BIC | CAIC |
|---|---|---|---|---|
| Default model | 3209.839 | 3233.194 | 3716.833 | 3833.833 |
| Saturated model | 2550.000 | 2804.501 | 8074.932 | 9349.932 |
| Independence model | 17361.788 | 17371.769 | 17578.452 | 17628.452 |

ECVI

| Model | ECVI | LO 90 | HI 90 | MECVI |
|---|---|---|---|---|
| Default model | 5.711 | 5.432 | 6.005 | 5.753 |
| Saturated model | 4.537 | 4.537 | 4.537 | 4.990 |
| Independence model | 30.893 | 30.143 | 31.654 | 30.911 |

HOELTER

| Model | HOELTER .05 | HOELTER .01 |
|---|---|---|
| Default model | 234 | 241 |
| Independence model | 43 | 44 |

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