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Understanding The Relationship Of Innovation And Quality In A Fast-Changing Market: An Automotive Industry Perspective

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UNDERSTANDING THE RELATIONSHIP OF INNOVATION AND QUALITY IN A FAST-CHANGING MARKET: AN AUTOMOTIVE INDUSTRY PERSPECTIVE

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DEDICATION

To My Husband and Friend, Greg Bell, My Children Eboni, Patrice, and Cory, and My Granddaughter, Aubrey

The journey toward completing this degree has been a labor of love. Thank you so much for your support as I create a legacy of life-long learners. You have stood by my side the entire way, and for that I dedicate this to all of you.

To My Parents, Peggy and Lee Spears and My Parents in Love, Pecola and Solomon Bell, Jr.

Thank you for your continuous encouragement during my educational journey. You always made me believe I could do anything, and for that I am truly grateful.

To my sister and brother, Monica and Gary

You have been my constant source of light with your encouragement and motivation to succeed, even in the midst of challenges along the way.

Love you all!

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My list of acknowledgements is extensive, so the best way for me to share my gratitude is through the story that describes my journey. The journey started much earlier than I describe below, but for purposes of these acknowledgements I must fast-forward to 2011.

This journey to PhD begins during the last semester of the Engineering Management Master's Program (EMMP). In my project management course, and as I finished up qualifications to receive my master's in Industrial Engineering, a young lady comes into the classroom to request participants for a research study. This young lady was Rachel Rié Itabashi-Campbell, a PhD candidate in the GET PhD program at Wayne State University. She looked determined to get the participants needed for her research and collected a few names along the way. I was admired by her courage to pursue a PhD, and thought to myself, "This might be a path for me". Thank you, Rachel, for coming to our class to look for research participants, you shed a light that you may not know existed.

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During the seven years that I was in the GET program, I moved in and out of six different leadership positions. I found it challenging to keep up with my coursework, which included researching various areas and, in some cases, writing thirty-page papers; it almost felt like this was going to be too much. But then there was another light; Drs. Julia Gluesing and Ken Riopelle. They encouraged me to join a small group of PhD students that would be known as the "Get it Done!" team. We met one cold winter day at Ken and Julia's home and shared our dissertation ideas. This was the breath of fresh air that I needed. Over the course of I believe three years, we all progressed our research, encouraging each other and sharing with one another our trials and tribulations; we all moved closer to "Getting it Done!" Julia and Ken were a constant source support, knowledge, encouragement, and love; just what I needed to get to this day in my life. They even came to visit me when I was in Silicon Valley.

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CHAPTER 1: INTRODUCTION

In a time when the consumer electronics industry is getting new products to market at a rapid rate, automotive original equipment manufacturers (OEM) must identify ways of getting new products and features to customers faster and with high quality to maintain or increase market share. This accelerated product development process requires a positive relationship between innovation and quality in order for a firm to have high performance in both strategic areas. Literature shows that there are mixed results on whether innovation and quality can coexist (Prajogo & Sohal, 2001).

The purpose of this dissertation is to research the impact that quality practices have on the advanced product development process. Specifically, this research will be focused on the innovations that are an expected outcome of the advanced product development process, or conceptual design process, in the traditional automotive industry.

In the automotive industry, and based on this researchers experience, a change in advanced product development speed is required to 1) remain competitive with the short life cycle of consumer electronics and 2) maintain a competitive advantage against the less traditional automobile competitors, such as Google, Apple, Tesla, and Chinese newcomers LeEco and BYD[1] (Gundling, 2016). New trends in automotive design including autonomous driving, in-car infotainment, and all-electric cars, require a different electronic vision and technologies for the automotive industry (Tummala, Wolter, Sundaram, Smet, & Raj, 2016). Gone are the days when traditional automobile manufacturers can take up to four years to introduce new products and technology; firms must look for ways to reduce the time-to-market for new, innovative ideas by

[1] BYD, originally a Chinese battery maker, sells large number of electric vehicles at half the price of many western models, buoyed by strong incentives from the Chinese government.

improving product flexibility (Frigant, 2016; Sanchez & Mahoney, 1996). The introduction of non-traditional automotive companies is challenging the historical automotive manufacturing model and status quo by improving product development time and time-to-market of passenger vehicles and mobility services. New companies in the mobility market such as Tesla, Local Motors, Google, and Uber are forcing traditional automobile manufacturers to revisit their normal product development practices, including innovation management.

Advancements in technology and product performance are introduced to customers through new product introductions, which ultimately impact customer choice and have an effect on productivity, quality, and market share (Clark, Chew, Fujimoto, Meyer, & Scherer, 1987). In some cases, fast-to-market technologies and innovation come at a price to a firm's customer satisfaction ratings[2]. In General Motors' 2018 Annual Report, the company outlines some of the risks associated with delivering their corporate plan. One of the risks involves the introduction of new technology, such as electric vehicles. The report states the following:

"…sale of electric vehicles is dependent upon consumer adoption, which could be impacted by numerous factors, including perceptions about electric vehicle features, quality, safety, performance and cost…"[3]

The challenge for the automotive industry is to achieve both technological innovation and maintain or improve quality and customer satisfaction at the same time. Literature on the future of quality management suggests there is significant opportunity for the development of stronger connections between innovation and quality (Blank & Naveh, 2014; Evans, 2013).

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[2] See Consumer Reports video "*Which Car Brands Make the Best Vehicles?", http://www.consumerreports.org/cars/which-car-brands-make-the-best-vehicles/*

[3] General Motors 2018 Annual Report, page 11

Throughout the years and based on this researcher's experience in the automotive industry, some cross-functional organizations, specifically conceptual design teams[4], have varying impressions and definitions of what they believe quality is and how adhering to quality tools and processes will impact the outcome of new technology or innovation being proposed. For example, there are some conceptual design teams that believe having a quality representative on their development team could limit their ability to gain approval to proceed with a new technology or advanced product design. They believe that if the quality organization does not endorse the new design because of potential customer satisfaction implications, then there is some risk that senior leadership will not approve the technology. There are others that believe that the use of today's quality tools and processes slow down the pace of developing fast-to-market technology. This research will seek to:

1) Understand how conceptual design and quality teams perceive the impact quality tools and processes have on quality performance and advanced product design performance of a traditional Fortune 50 automotive firm.
2) Understand if conceptual design teams and quality teams share the same language and terms for quality and innovation and share the same meanings for these terms; there is a possibility that the meaning of words and terms are different. If the language and meaning is different this study will attempt to identify a common language that will bring communication between the two teams closer together, and that will be one conducive to delivering fast-to-market advanced product designs that are expected to have a positive impact on customer satisfaction.

[4] Conceptual design is "is an umbrella term given to all forms of non-aesthetic design management disciplines", which include innovation management. The term conceptual design team is used instead of research and innovation organization to ensure the work of innovation design teams could be included in this study.

3) Understand the cultures of these conceptual design and quality teams to learn if these cultures are conducive to fast-to-market advanced product design.
4) If there are cultural elements that are not conducive to fast-to-market advanced product designs, propose enhancements that will increase the culture elements that are conducive to fast-to-market advanced product design.

In this researcher's experience at a Fortune 50 automotive manufacturing firm, the role of enforcing the timely resolution of product defects and improvement to customer satisfaction has been the charter of the quality organization. The quality organization works directly with the manufacturing and product development organizations to ensure the risks of product defects and customer dissatisfaction are minimized or eliminated. In the case of new and advanced product features and technologies, the quality organization works with the engineering team early in the product development phase ensuring these new features and technologies have a robust failure mode avoidance[5] plan, one that includes understanding the technology's quality history and the impact that it has had on customer satisfaction. The quality history is used along with other essential failure mode avoidance tools to help develop a good design failure modes and effects analysis, or DFMEA. There are some cases when the technology or feature being considered is so new that a quality history cannot be fully realized; neither the design engineer nor quality engineer really knows how customers will respond to this new technology or where potential error states may occur with these conceptual designs. Missing the ball in advanced product design has the

[5] "Failure Mode Avoidance (FMA) strategy adopted by Ford Motor Company (Henshall, 2009; Davis, 2007; Zhou 2005) is, in simple terms, a pragmatic approach to ensure that potential failure modes are systematically identified and robust countermeasures implemented and verified early in the design process. The FMA approach targets all sources of potential failure modes including business, technical and procedural (Henshall, 2009; Davis, 2007), and is fundamentally based on the belief that early identification of failure modes is ultimately a matter of common sense engineering, supported by a structured framework and a set of well proven engineering tools."(Henshall, 2009)

potential to negatively impact customer satisfaction[6] once the new product is introduced into the market.

In reviewing the 2018 Ford Motor Company Annual Report[7], Ford states

"…we have generated a large number of patents, and expect this portfolio to continue to grow as we actively pursue additional technological innovation. We have approximately 60,000 active patents and pending patent applications globally, with an average age for patents in our active patent portfolio of just over four and a half years."

While there is no guarantee that all of these patents translate into new products, it is an indication that advanced product designs and innovation will continue to be a driving force to the company's competitive positioning. In the article "Explosion of New Products Creates Challenges", authors Miles Maguire and Mark Hagen (1999) suggest that this type of innovation explosion creates significant challenges for quality practitioners. They go on to say "that while quality experts will be consulted for their quality knowledge and skills, they must also be ready to master new tools and techniques while giving careful consideration to how quality may be redefined and understanding what quality means in an environment of rapid change and increasing customer expectations" (Maguire and Hagen 1999, p.30).

A literature has developed over the past three decades on the relationship between quality and innovation. This literature includes showing that quality and innovation have: 1) both a positive (Chandra, 1993; Dean & Evans, 1994; Kanji, 1996; Prajogo & Sohal, 2004; Roffe, 1999; Tang, 1998) and negative (Glynn, 1996; Kanter, 1984; Slater & Narver, 1998; Tidd, Bessant, &

[6] Customer satisfaction can be explained using the Kano model. Kano's model of customer satisfaction includes three different elements. The first is "Must-Be" requirements and these are basic criteria of a product; if these requirements are not met the customer will be extremely dissatisfied. The second is One-Dimensional requirements, which are those requirements that are explicitly demanded by the customer; these requirements are linked to stated, specified, measurable, or technical performance (i.e. gas mileage). The third and final requirement is "Attractive" requirements and is the product criteria that have the greatest influence on how satisfied a customer will be with a product; if these requirements are not met, there is no feeling of dissatisfaction. Attractive requirements are customer surprises and delights. (Matzler & Hinterhuber, 1998)

[7] Ford Motor Company 2018 Annual Report, page 20

Pavitt, 1997; Wind & Mahajan, 1997a) relationship; 2) a relationship such that innovation must be built on a foundation of quality (Flynn, 1994); 3) a hypothesized common denominator between quality and innovation of customer value (Ng, 2009); 4) an alignment of quality management principles to innovation (Pfeifer, Siegler, & Varnhagen, 1998; J. Zeng, Phan, & Matsui, 2015); and 5) an impact on corporate performance from an organizational culture point of view (Miron, Erez, & Naveh, 2004).

Literature related to the intersection of quality and innovation has also emerged in the marketing field. Scholars delve into the impact interdepartmental connectedness and conflict have on product quality in the presence of technological turbulence (Menon, Jaworski, & Kohl, 1997), and the impact that a cross-functional team's information flow and the influence customers have on advanced product development during the early stages of the product development process (Sethi, 2000). The literature is silent however, on how engineers working in conceptual design and those working in quality understand each other and the meaning of innovation and quality, and their respective roles in ensuring advanced product designs deliver a positive customer experience.

This research is intended to contribute to the field of engineering by raising awareness about the factors that support the successful development and implementation of fast-to-market technologies where quality, including customer satisfaction, is key to corporate performance and improved market share. The three primary research questions guiding this study of innovation and quality are as follows:

1. How do engineers working in conceptual design and those working in quality understand each other, the meaning of innovation and quality?

2. What is the organizational culture of conceptual design teams and the quality organization? Are they the same or different, and how do these cultures potentially impact a successful quality or advanced product design outcome?
3. How do the interdepartmental interactions of conceptual design and quality impact the output of advanced product designs?

The research questions are informed by both the practical problem of maintaining quality as the automotive industry faces a compressed product development cycle along with the accelerating demand for innovation and by a body of literature about quality and innovation and how they come together in the organizational context. The next section provides a review of the literature that informs this proposal study.

CHAPTER 2: LITERATURE REVIEW

To answer the three research questions, the study will draw upon literature in the following domains: Innovation, quality, and their intersection, organizational culture, organizational structure and networks, information exchange, and interdepartmental interactions. This section of the proposal provides an overview and definitions of each of these concepts for the purposes of this study and describes their contribution to a conceptual model that will guide the research and propositions derived from the model.

Innovation

Everett Rogers in his book "Diffusion of Innovation", defines an innovation as "an idea, practice, or object that is perceived as new by an individual or other unit of adoption (Rogers, 2003, 2010). If an idea seems new to the individual, it is an innovation." This research study will build on the definition of an innovation as an idea, that occurs early in the product development process, well before it reaches the end user.

Scholarly research tells us that innovation has become increasingly important to the survival of any organization (Stenmark, Shipman, & Mumford, 2011). Maintaining a competitive advantage with current processes, products, or services of an organization are no longer sustainable. On the contrary, they must strive to continually create new products and processes to achieve long-term success (Dess & Picken, 2001; Tushman & Anderson, 2004). The way innovation is managed within a firm can mean the difference between long-term success and early demise (Stefflre, 1985).

Saleh and Wang's (1993) research on innovation management shows significant differences between the structures of highly innovative and less innovative organizations. In addition to having an entrepreneurial strategy and rewarding climate, these authors argue that an innovative

organization should have a structure that is flexible, synthesized, and have a collective orientation[8] (S. D. Saleh & Wang, 1993).

Quality

Quality as defined by American Society of Quality, or ASQ, is *"A subjective term for which each person or sector has its own definition. In technical usage, quality can have two meanings: 1. the characteristics of a product or service that bear on its ability to satisfy stated or implied needs; 2. a product or service free of deficiencies. According to Joseph Juran, quality means "fitness for use;" according to Philip Crosby, it means "conformance to requirements."*

A review of the literature on quality focuses on customer satisfaction and integrating quality tools and practices into all processes and functions of an organization to remain competitive (Lockamy & Khurana, 1995). The seminal of works of Deming (1982), Juran (1988), and Ishikawa (1985) set the foundation for scholars to establish the impact of quality on an organization and the important factors required for improved quality performance.

It has been said that quality management or QM leads to continuous improvement that focuses on incremental improvements and that it requires formalization and standardization to establish control and stability (Imai, 1986; Jha, Noori, & Michela, 1996; H.-B. Zeng, He, Wu, & She, 2015).

Intersection of Innovation and Quality

The study of innovation and quality introduces a new set of scholarly research studies. There are both qualitative and quantitative research studies to draw upon.

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[8] According to Driskell, J. E., et al. (2010) *collective orientation* is defined as the propensity to work in a collective manner in team settings. Driskell, Salas, and Hughes (2010)

Literature about the relationship between Total Quality Management (TQM) and innovation is conflicting (Prajogo & Sohal, 2001). Based on a literature review of this relationship, Prajogo and Sohal (2001) show that there are arguments in support of a positive relationship between TQM and innovation, and there are arguments that do not support the relationship between the two corporate strategies. Research that argues in favor of the positive relationship between TQM and innovation state that TQM principles and the integration of these principles into a company's system and culture provide a productive environment that encourages innovation (Alotaibi, Yusoff, bin Mohd Mokhtar, & bin Taib; Chandra, 1993; Dean & Evans, 1994; Gkana, 2014; Kanji, 1996; Long, Kowang, & Wan Ismail, 2015; Ooi, Lin, Teh, & Chong, 2012; Prajogo & Hong, 2008; Tang, 1998; Zehir, Ertosun, Zehir, & Müceldilli, 2012). The TQM principles that support this argument include customer focus, continuous improvement, empowerment, involvement and teamwork (Prajogo & Sohal, 2001). There also are some innovation management best practices (Zairi, 1999) that are recognized as TQM elements. These best practices include quality culture, learning organization, customer-driven organization, and continuous improvement (ibid, 1999). Literature that supports the positive relationship between quality and innovation suggests that personal characteristics and culture (Miron et al., 2004), attention to detail (Naveh & Erez, 2004), product quality as a determinant of innovation (Lin & Lu, 2006), customer value (Ng, 2009), and the dimensions of quality management (QM) (J. Zeng et al., 2015) all play a role in the coexistence of quality and innovation.

There is also an opposing view regarding the relationship between TQM and innovation. This group of arguments claims that the principles of QM are not compatible with innovation (J. Zeng et al., 2015). Some researchers raise the point that TQM philosophies and practices could prevent organizations from being innovative (Prajogo & Sohal, 2001). Wind and Mahajan (1997b)

and Hamdoun et al (2018) suggest the customer focus philosophy could lead to organizations only focusing on incremental improvements instead of novel solutions, which equates to product conformance rather than real innovation. Continuous improvement is also identified as a TQM element that inhibits innovation by stressing incremental change rather than radical change (Imai, 1986). Scholars make the case that there is no significant statistical data that supports a positive relationship between innovation and quality (Singh & Smith, 2004) after surveying more than 400 Australian manufacturing organizations. Other researchers found that TQM culture has a direct influence on product design and process improvements, but not on product innovation (Miranda Silva, J. Gomes, Filipe Lages, & Lopes Pereira, 2014). Palm et al. (2016) suggest that integrating and achieving balance between quality and innovation is a difficult task, and that current quality management practices lead to a decreased scope for innovation. This study will test whether these conflicts exists with conceptual design teams and the current quality management practices.

The research framework of Prajogo and Sohal (2001) stresses that organizational culture has an impact on quality performance and innovation performance. Based on a review of the literature, there are studies that have investigated the impact organizational culture has on the relationship between innovation and quality. After reviewing the literature, Valencia et al. (2010) speak to the impact that organizational culture has on innovation and quality by suggesting through a literature review that while adhocratic cultures could enhance the development of new products or services, hierarchical cultures inhibit product innovation. The proposed study will examine the impact that organizational culture has on innovation performance and quality performance, specifically the culture of conceptual design teams and quality teams and is expected to provide further insight on this complex relationship. Cameron and Quinn (1999; 2011), who understand organizational cultures as the underlying glue that binds the organization together, suggest that a

researcher can focus on the entire organization as a unit of analysis, or assess subunit cultures, thus identifying common dominant attributes. This study will do the latter, focusing on conceptual design teams and the quality organization of a Fortune 50 automotive firm.

Further studies show mixed results regarding the relationship between quality performance and innovation performance. Some of the studies suggest the configuration of TQM practices implemented in different ways creates varying outcomes in the relationship between quality and innovation (Moura E Sá & Abrunhosa, 2007; Prajogo & Sohal, 2004). Abrunhosa and Moura (2008) investigate the impact of TQM organizational requirements on the relationship and find that the 'soft'[9] elements of TQM correlate positively with technological innovation. However, the features of the mechanistic[10] model of TQM are a constraint on the relationship between quality and innovation (ibid, 2008). Mushtaq et al. (2011) present a framework that indicates the quality and innovation relationship is interlocked with a firm's area of expertise. Leavengood, Anderson et al. (2014) suggest firms successful at quality performance only focus on customer complaints and view innovation as a result of some other business goal; however, those successful in both quality and innovation seek to understand customer needs.

The American Society of Quality (ASQ) administers the Baldridge Performance Excellence award that assesses multiple corporate strategies. These strategies include innovation, quality, and knowledge management. Knowledge management involves the exchange of information among organizations (Blank & Naveh, 2014). Blank and Naveh (2014) used this concept as the basis for their research in understanding how an information exchange climate

[9] Soft Quality Management elements promote the human aspects of quality management and are defined as the QM practices which are directed toward the involvement and commitment of management and employees, learning, training, and internal teamwork (J. Zeng et al., 2015)

[10] The Mechanistic model of TQM includes strategic planning, customer focus, information and analysis, and process management. (Prajogo & Sohal, 2004)

moderates the relationship between innovation performance and quality performance. Their research was specific to team members in four large high-tech electronics companies involved in software programming research and development. While the results of their research were also mixed, their study shows that when the information exchange climate is high, the innovation climate significantly improved quality performance. However, when the information exchange climate is low and the innovation climate is high, quality performance degrades (Blank & Naveh, 2014). The present study will test the framework of Blank and Naveh (2014) to better understand the impact that information exchange has at the team level, specifically among conceptual design teams and quality teams, on both the quality performance and advanced product design performance of a mature automotive firm.

Organizational structure has been identified as an important factor in the quality performance (Brooks Jr, 1995; Nagappan, Murphy, & Basili, 2008) and innovation performance (Shoukry D Saleh & Wang, 1991; Vadastreanu, Bot, Farcas, & Szabo, 2015) of an organization. Douglas and Judge (2001) explore the relationship between the degree to which quality management (TQM) practices are adopted within organizations and the corresponding competitive advantages achieved (i.e. quality performance and innovation performance). Their data showed some support for the moderating influence of organizational structure on TQM implementation effectiveness (Douglas & Judge, 2001). Zehir et al. (2012) suggest that more studies are needed to test different samples and organizational characteristics for effects of TQM on quality performance and innovation performance. To this researcher's knowledge, there is very little literature related to the impact organizational structure has on the relationship between quality and innovation.

Interdepartmental interactions have two primary aspects: interdepartmental connectedness and interdepartmental conflict (Menon et al., 1997). Interdepartmental connectedness refers to the degree of formal and informal direct contact among team members across departments (Jaworski & Kohli, 1993). Interdepartmental conflict is "the tension among departments arising from incompatibility of actual or desired responses and goals" (cf. Raven and Kruglanski 1970, p. 70). Connectedness between areas should facilitate a rapid response in an environment that is turbulent and where technology is rapidly changing (Menon et al., 1997). Olson, Walker Jr, and Ruekert (1995) suggest that structuring the organization to foster positive interdepartmental connectedness is critical to the effectiveness of the product development process, particularly for truly innovative products. There is literature that shows product quality is impacted by interdepartmental connectedness (Menon et al., 1997). However, the literature is silent on how interdepartmental interaction impacts the relationship between quality and advanced product design.

Based on this researcher's experience, some conceptual design teams believe the quality organization adds risk to delivering new technology and innovation by imposing a "things gone wrong" assessment on new technology. Some conceptual design teams also believe that quality tools and processes slow down the innovation process; this slowdown causes interdepartmental conflict. This perception leads to conceptual design teams rejecting the membership of quality personnel on the team, thus there is low interdepartmental connectedness. Drawing on the literature, this study will understand if this perception is true by investigating the mediating role of interdepartmental interactions on the team culture and information exchange of conceptual design teams and quality teams of a Fortune 50 automotive firm, and the associated impact on the firm's quality performance and innovation, or advanced product design performance.

CHAPTER 3: CONCEPTUAL MODEL

This section of the study presents the conceptual model that guided a mixed methods research design to discover how engineers in conceptual design and those in quality understand each other, the meaning of innovation and quality, and the impact that culture, information exchange and interdepartmental interactions has on advance product design and quality performance.

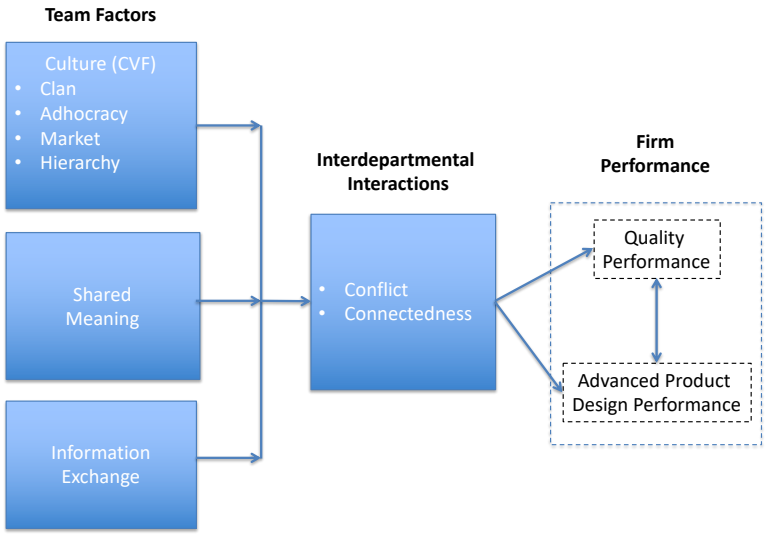
The conceptual model (See Figure 1) identifies the general relationship between quality and innovation team factors, interdepartmental interactions, and firm quality performance and innovation performance. The framework illustrates that there is an influential relationship between interdepartmental interactions and quality and innovation performance. There are also three team factors that influence interdepartmental interactions; team culture, shared meaning, and the information exchange among members of different organizations responsible for quality and advanced product design.

Propositions are established based on the literature. The propositions stated illustrate the relationships among the team factors of culture, shared meaning, and information exchange, specifically through interdepartmental interactions, and how together they influence advanced product design performance and quality performance.

A key area of focus for this research is to understand the organizational cultures of both the quality organization and the conceptual design or innovation teams of a mature firm. Research shows that a culture of innovation and a culture of quality are different and require different leadership styles (K. S. Q. Cameron, Robert E. , 2011). Edgar Schein (1992, 2010) defines organizational culture as “a set of basic tacit assumptions about how the world is and ought to be

that a group of people share and that determines their perceptions, thoughts, feelings, and to some degree, their overt behavior" (Schein, 1992, 2010).

Figure 1: Conceptual Model



Herbert Shepard (1967) suggests that a culture supportive of innovation will be innovation-producing and a culture that is not supportive will be innovation-resisting. An innovation producing organization is continually learning and adapting to changes internally and in its environment (Shepard, 1967). Supportive cultures in the innovation-producing organization accept good ideas; ideas are not turned away, they recognize team members at all levels for good ideas, and they ensure the involvement and commitment of management in the innovation process.

On the other hand, an innovation-resisting culture puts up strong defenses against innovation (Shepard, 1967). Shepard suggests that this type of culture, like a factory, wants to ensure a reliable repetition of prescribed operations. Scholars who argue that innovation is often performed reluctantly in response to challenges (Miller & Friesen, 1982) point in particular to risks that stem from adapting to changes (S. D. Saleh & Wang, 1993; Shepard, 1967).

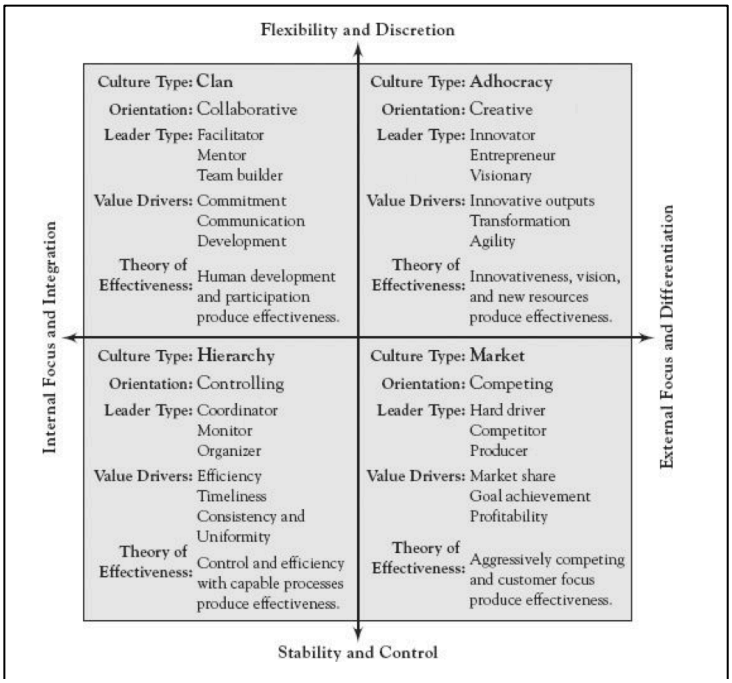
Culture

Diagnosing and Changing Organizational Culture was written by Kim Cameron and Robert Quinn (2011) in an effort to educate managers, teachers, and change agents how to diagnose and initiate change in an organization. Their Competing Values Framework is a theoretical model that can be used to help understand an organization's cultural makeup and where it believes it should be to achieve its performance goals. Figure 2 illustrates the four categories or clusters of criteria that establish the model for the competing values framework. These four clusters of criteria define the core values that are used to make judgments about an organization's culture.

The four core values represent opposite and competing assumptions. The dimensions are shown in quadrants with each quadrant showing a core value that competes with the core value diagonal to it. For example, clan or collaborate versus market or compete and adhocracy or create versus hierarch or control. The y-axis and x-axis show the culture range. From flexibility and discretion to stability and control on the y-axis, and from internal focus and integration to external focus and differentiation on the x-axis. Figure 2 provides more insight into the various characteristics for all four cultures.

According to scholars, a hierarchical culture would be rigid and would inhibit innovation by requiring people to focus on the quality processes rather than on the introduction of new ideas and processes (Glynn, 1996; Morgan, 1993; J. Zeng et al., 2015). This characterization is in line with the works of Imai (1986), Jha et al. (1996), and J. Zeng et al. (2015), mentioned previously, in that an organization that is focused on QM requires formalization, standardization, and control. An innovative organization from a cultural standpoint is linked directly to a culture of adhocracy (K. S. Q. Cameron, Robert E. , 2011), which is in the upper right-hand quadrant of the competing values framework.

Figure 2: Competing Values Framework (Cameron, 2011)



Based on the literature and this researcher's experience, the following propositions are suggested:

Proposition 1: Conceptual Design teams will have an Adhocracy culture type.

Proposition 1a: The Quality organization will have a Hierarchy culture type.

Proposition 1b: An organizational culture of adhocracy will be positively related to Interdepartmental Interactions.

Proposition 1c: An organizational culture of hierarchy will be negatively related to Interdepartmental Interactions.

Information Flow

The implicit function of a network is information flow (Borgatti & Halgin, 2011). According to Borgatti and Halgin (2011) the network flow model is the most developed theoretical platform in network theory. More recent research by Leenders and Dolfsma (2016), provides

details on social networks and the information flow within new product development (NPD)[11] teams. The authors suggest innovation is a collaborative effort and that as separate knowledge from different networks comes together new knowledge emerges. They explain that NPD teams are information-processing units that process information by encoding, storing, and retrieving that information. And that their ability to be innovative can be enhanced by properly managing communication among the members of the team (Leenders & Dolfsma, 2016).

To understand the communication or information exchange of the conceptual design network and the quality network, it is important to study the language of these respective teams. For this study, the research focuses on understanding the semantic attributes of the teams. Semantic attributes for an entity are linguistic code identifiers, such as the name of a person, organization, or object (Danowski, 2013). These semantic attributes are like the words in a dictionary or elements of an ontology (ibid, 2013). Analyzing the semantics of the conceptual design and quality teams will be helpful in understanding if their languages are the same or different, and how they understand each other. The following statements can be proposed:

Proposition 2a: The language of the conceptual design team(s) will be different than the language of the quality team.

Proposition 2b: The meaning of innovation and quality as understood by the conceptual design team(s) will be different than the meaning as understood by the quality team.

Organizational Structure and Networks

Organizational structure can also have an impact on a team's ability to be innovative (Rogers, 2003, 2010). Dougherty and Hardy (1996) argue that an organizations ability to sustain product innovation is related to the structure of the organization. Organizational structure is

[11] In this research, NPD (new product development) is synonymous with conceptual design and innovation.

important because it is a means for achieving the objectives and goals of an institution; thus any changes to structure must start with the institutions objectives and strategy (Drucker, 1974). According to Saleh and Wang (1993) and their research on innovation management, the organizational structures of highly innovative and less innovative organizations are significantly different. The authors argue that an innovative organization should have an entrepreneurial strategy and rewarding climate as well as a structure that is flexible, synthesized, and that has a collective orientation (S. D. Saleh & Wang, 1993).[12] It has been argued that long-stable organizations are challenged by changes in global competition and technology; in order for them to survive they must become more innovative, but this step requires them to fundamentally change how they are organized. (Hage, 1999)

To establish a good understanding of the dynamics between conceptual design engineers and quality engineers, it is important to understand networks and the role they play in organizational structure. Networks are increasingly seen as an ideal structure that allows one to organize and think conceptually about groups or organizations that have the objective of working together collaboratively (Borgatti & Halgin, 2011). According to Borgatti and Halgin (2011, p. 1169), "a network consists of a set of actors or nodes along a set of ties of a specific type that link them. The ties interconnect through shared end points to form paths that indirectly link nodes that are not directly tied. The pattern of ties in a network yields a particular structure, and nodes occupy

[12] A flexible structure is one that can quickly change to meet modified objectives that are driven by external and technical circumstances and is decentralized with the team viewed as having many sources of power and influence; a synthesis structure is one that is collaborative, drawing on the knowledge of internal and external teams; and collective orientation refers to the concept of teamwork; it provides a sense of community of purpose and a sense of trust which are important for successful innovative technical teams. The collective team is rewarded as a result of a successful innovation. Saleh, S. D. and C. K. Wang (1993). "THE MANAGEMENT OF INNOVATION - STRATEGY, STRUCTURE, AND ORGANIZATIONAL-CLIMATE." Ieee Transactions on Engineering Management **40**(1): 14-21.

positions within this structure. Network theory refers to the mechanisms and processes that interact with network structures to yield certain outcomes for individuals and groups".

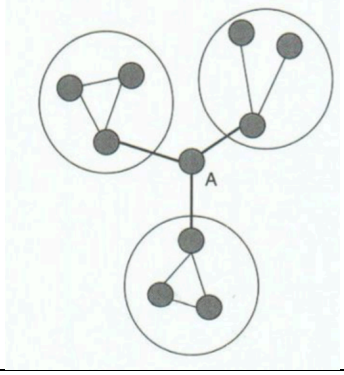
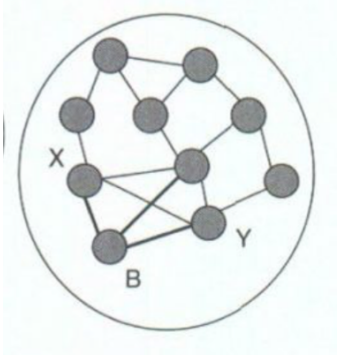
Borgatti and Halgin (2011) give a detailed overview of network theory. They explain in the article "On Network Theory", that the choice of nodes for research is dictated by the research question and ones explanatory theory. The article provides details on network theory, including bridge ties, node egos, types of social ties, Strength of weak ties theory (Granovetter, 1973), Structural holes theory (Burt, 2009), characteristics of Network theory, and goals of network theorizing.

For this research the network structure for conceptual design teams and quality teams are investigated. The nodes are the individual engineers that are in these networks. Burt (2009) argues that a network structure with more gaps (see Figure 3) will be more likely to receive less redundant information, which in turn will enable the network to perform better or be perceived as the source of new ideas. Based on this researcher's experience, some conceptual design teams are assembled temporarily to develop new technologies, similar to a skunk works team.[13] These types of teams are isolated from corporate day-to-day activities, only reaching out to other teams and organizations to get information that will help advance their project. Also based on this researcher's experience, quality teams normally have a cluster of engineers that all know the same information and that work to enforce tools and processes that are expected to ensure a high level of quality. These engineers only interface with conceptual design teams when prompted for information or when requested, thus creating a weak link to the conceptual design team. Because of the temporary nature of a conceptual design team that works on fast-to-market technology or

[13] A skunk works team is a small groups of scientists, engineers and other personnel who tackle specific problems and try to commercialize the solutions (Gwynne, 1997)

innovation and based on this researcher's experience with quality teams, the following propositions are offered:

Figure 3: Network Structures

a) Network with more structural holes	b) Network with fewer structural holes
	

Proposition 3a: Conceptual design teams will have a network that has more structural holes.

Proposition 3b: Quality teams will have a network that has fewer structural holes than the conceptual design teams and will have a loosely linked interface to the conceptual design team.

Proposition 3c: Team Culture will be significantly and 1) positively related to a network structure with more structural holes and 2) negatively related to a network structure with fewer structural holes.

Proposition 3d: Shared meaning will be significantly and 1) positively related to a network structure with fewer structural holes and 2) negatively related to a network structure with more structural holes.

Proposition 3e: Information Exchange will be significantly and 1) positively related to a network structure with more structural holes and 2) negatively related to a network structure with fewer structural holes.

Additionally, based on the literature and this researcher's experience, the following additional propositions are proposed relative to the team factors and Interdepartmental Interactions:

Proposition 4a: The greater the Interdepartmental Conflict between conceptual design and quality engineers, the lower the quality performance and advanced product design performance

Proposition 4b: The greater the Interdepartmental Connectedness between conceptual design and quality engineers, the higher the quality performance and advanced product design performance

CHAPTER 4: RESEARCH DESIGN AND METHODS

This research will use a Convergent Parallel Mixed Methods approach where both qualitative data and quantitative data will be collected, analyzed separately, and then the results will be compared separately to see if the findings confirm or disconfirm each other. This triangulation will promote robust results. The assumption is that using both qualitative and quantitative data will provide a more complete understanding of the research problem than if only one approach is used alone (Creswell, 2014).

The research will focus on technologies being pursued in the automotive industry, specifically at a Fortune 50 automotive firm; hereto referred to as "the firm". The research tools used for this study were interviews with executives of the firm and a survey that was issued to the members of the research and advanced engineering, product development, and quality organizations of the firm. The interviews were completed and analyzed before the survey, in an effort to inform the content of the survey.

Interview Construction and Linguistic Research Tools

The interview tool was designed to yield information about the beliefs, values, and norms that are present in advanced product development by the firm's executive leadership. The structure of the interviews and the questions were designed to elicit the perceptions of innovation performance and quality performance based on the interdepartmental interactions of conceptual design teams and the quality organization, as well as the cultures, subcultures, languages, and information exchange that may exist between them. The interview questions were worded to capture the team members' experiences.

Prior to the interviews, a participation letter was sent out to the proposed interviewees for consideration (See Appendix A for the Interview Participation Letter). It was explained and

enforced that the interviews would be strictly confidential. During the interview each interviewee was asked if they agreed to have the interview recorded. The interview transcript can be found in Appendix C. For those participants that agreed to have the interview recorded, the taped interview was transcribed after the interview for analysis. For those participants that did not agree to the interview being recorded, these interviews were taken in note form and uploaded as such for the analysis. To ensure a high level of trust between the interviewer and interviewees, a confidentiality agreement was offered to the participants. None of the participants requested a confidentiality agreement. All of the requests for interview were granted, with each participant eager to share their views on the intersection of innovation and quality. There was only one interview that had to be rescheduled; all others kept their original time, with some going over the time that was allotted. This commitment to the interview gave confidence that the participants would provide rich input for this study. Each interview lasted between 30 and 60 minutes. Twenty of the firm's executive leaders participated in the interview process in Michigan and Northern California, which are the locations of the firm's engineering and research facilities.

Interview transcripts were analyzed using Wordij, Linguistic Inquiry and Word Count (LIWC), and Atlas.ti to examine shared meaning in the context of organization's work and daily interactions. The sections that follow will be provide insights into each of the managerial categories for Wordij and LIWC. An analysis of the interview data will be provided as a consolidated view of the messaging for all of the interviews together in Chapter 5.

WORDij[14]

After all interviews were transcribed or notes completed, the interviews were analyzed with WORDij. WORDij is a tool to map and analyze text to understand it through semantic

[14] http://www.wordij.net/about.html

networks. This method captures the relationships among words within the message to establish a network perspective. The strength of word-pair links will also be defined as the number of times each work occurs closely in text with another. The value range of all possible word pair occurrences allows for the use of statistical tools for social network analysis.

Each transcription and various combinations of transcriptions went through a series of steps to put them in a form that could be used for the WORDij tool. First, the .doc file was converted to a .txt file, this file format was used for future analysis processes. In the WORDij tool, and once the .txt file was uploaded, WordLink, a function within WORDij, was initiated. WordLink produces custom semantic networks from various files that are created when the function is activated, three of which are a .net file, a .wrd file and a .pr file. A drop list of words that are commonly used in interviews was used to ensure high volume words were omitted from the analysis. There was one participant that used the word "Um" throughout the interview. the drop list included the word "Um" so that it wouldn't surface as one of the keywords in WordLink or the other WORDij programs. These files were used later in the analysis process. The .wrd file and .pr files were used to understand word and word pair frequencies, respectively. Being able to view the word and word pairs gives an opportunity to visualize how each of the leaders thinks about innovation and quality. All interviews were analyzed individually, in their respective groups, and collectively. To get a better sense of insights and themes, one the group analyses will be reported in Chapter 5.

Other elements of the WORDij tool that were used include the VISij, QAPnet, OptiComm, and Z-Utilities programs. VISij uses the .net file that was generated during the first stage of the WORDij process an provides the visualization of a word network. VISij enables the user to change the graphic image of a network by zooming in and out, excluding disconnected nodes and varying

the number of nodes displayed as well as the link strength between nodes. The QAPnet program is an overall measure of the similarity of two whole networks using a correlation coefficient. QAPnet utilizes the .pr files to compare two individuals or groups. The output is a correlation value that ranges from -1.00 a perfect negative correlation to +1.00 a perfect positive correlation. The results of the QAPnet exercise were documented in a matrix for further evaluation to understand which of the interviewees were correlated and those that were not correlated. The optimal message center, OptiComm, program was also utilized for this study. The purpose of the OptiComm feature is to produce messages that could be used to either promote change to move two words closer, move them further apart, or to reinforce aspects of the semantic networks. OptiComm traces the shortest paths between a seed word and a target word, both of which must be connected indirectly to the network. For this study, OptiComm was used to understand the word paths for the various groups; the group details were then analyzed and compared for differences in messaging. The last WORDij program used for this study was the Z-Utilities program. the Z-Utilities program allows the user to compare two text files to determine what the significant differences there are for either the words or the word pairs of an interview. The Z-Utilities determine what words and word pairs are new and growing, what is old and declining, and what remains the same in relative frequencies. The Z-utilities determine what words and word pairs are new and growing, what is old and declining, and what is remaining the same in relative frequencies (proportions). Although these are called Z-Utilities, there are actually two significance tests for comparisons of words, pairs, and the pairs output of the .net files. One is the Z-test for proportions, or relative frequencies and the other is the Chi-Square tests of differences in counts. The Z-test cannot produce a value when one of the pairs has a frequency of zero, so a very small constant is inserted to replace zero. The critical z value for two proportions are:

$p < .05$ is + /- 1.64,

$p < .01$ is +/- 2.389

$p < .001$ is +/- 3.5

The Chi-Square test may be preferred by some analysts because it is not an inferential statistic whereas Z-tests are. Nevertheless, if the number of occurrences in one or both of the files is less than 5 then Chi-Square statistics should not be used because the estimates are invalid. The value of Chi-Square that is statistically significant for degrees of freedom 1 and $p < .05$ (number of cells -1) is 3.841. Values higher than this are significant at higher levels. For example:

$p < .01$ the critical value is 6.635,

$p < .005$ is 7.879.

The output of each of these WORDij functions are shown in Chapter 5.

Linguistic Inquiry and Word Count (LIWC)

LIWC was used to analyze the text and assess the positivity and negativity of the text collected from the interviews, from the documents collected, and from open-ended survey comments. The positivity score was calculated for every interview and for the various groups. To get the positivity scores LIWC was initiated and the Analyze Text function was selected. A select text box surfaces and allows the user to select the .txt file to analyze. The respective file was chosen for the required analysis. The resulting analysis opened in a matrix format and was saved as a .xls file. Two of the values calculated were the negemo and posemo, in addition to other linguistic calculations. To get the positivity index, the posemo value was divided by the negemo value. To add this to the LIWC file, a column was added, and the calculation was added to the new cell. This step was completed for every interview and combined group analysis. The file was saved as a .pdf file and loaded into Atlas.ti for tracking and reference.

For this study, the LIWC positivity scores ranged from 13.1, which is the most positive interview, to 1.0, which was the least positive interview. Once the positivity scores were established for each of the interview participants individually, all interviews were combined into one file and analyzed for the combined positivity score. The positivity scores for the interviews can be found in Chapter 5.

Atlas.ti

Atlas.ti was used to analyze the interview results. The output from Atlas.ti was used to inform the survey content that was distributed to the firm's quality and conceptual design team members. Atlas.ti is a computer program used for the quantitative analysis of large bodies of textual, graphical, and video data. Atlas.ti has a function that facilitates the creation of relations among codes in a network view for grounded theory development.

For this study, this researcher's experience as a member of the quality and research and innovation organizations in a Fortune 50 automotive firm will be beneficial in analyzing the data that will explain the relationship between conceptual design and quality engineers.

Survey Construction and Operationalization of Constructs

In addition to interviews with firm's executives, members from three different organizations of the firm participated in a survey to assess the relationship of culture, information exchange, and interdepartmental interactions on advanced product development and quality performance. A letter was sent to more than 4,900 of the firm's employees requesting participation in the study. It was explained that the study designed to understand the intersection of innovation and quality in a mature firm. A copy of the letter and the final survey can be found in Appendix D. Relative to innovation, conceptual design team members were recruited from the research and advanced engineering and product development organizations to participate in the research. For

the quality perspective, quality professionals from the quality organization were recruited to participate in the survey. In the survey, each participant was asked if their experience with conceptual design was as a member of either the advanced product design team, the quality team, or both; hereto known as the "hybrid" group. This information would be used during the analysis to see if there was a difference in language and shared meaning based on their experiences.

For the survey, multi-item scales were used to ensure adequate measurement of each variable. Previously established scales will be used where suitable. Reliability of the measures were assessed using Cronbach's (1951) alpha coefficient. The instrument developed in this study consists of three major parts. These parts include team culture, information exchange, and interdepartmental interactions. Table 1 shows the scales used and the number of items employed to quantify each construct. The construct definitions and measures are explained in the following section.

Construct Definition and Measures

Team Culture

To measure team culture the Organizational Culture Assessment Instrument (OCAI) from the Competing Values Framework by K. S. Q. Cameron, Robert E. (2011) was distributed as a part of the complete survey to all members of research and advanced engineering, product development, and quality. The objective of the OCAI is to assess six key dimensions of organizational culture. These dimensions include:

- Dominant Characteristic – of the organization or what the overall organization is like
- Organizational Leadership – the leadership style that permeates the organization
- Management of Employees – the style that characterizes how employees are treated
- Organizational Glue – the bonding mechanism that holds the organization together

- Strategic Emphasis – the area of emphasis that drives the organization's strategy
- Criteria of Success – how victory is defined and what gets rewarded

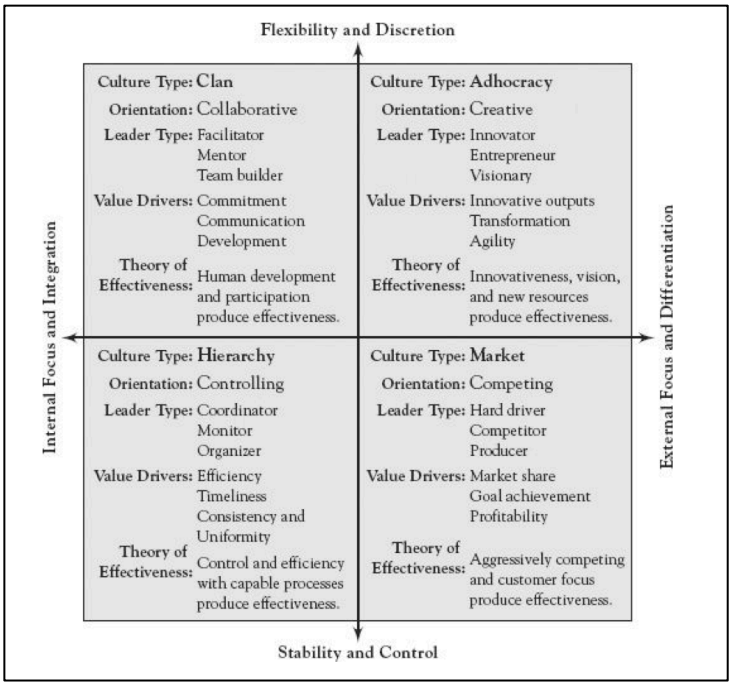
The six OCAI consists of four options that are aligned with the Competing Values Framework culture types; clan, adhocracy, market, and hierarchy (see Figure 4). A 5-point Likert scale was used to assess each of the characteristics independently as perceived by the respondents, which was explained in the survey as NOW, and how they believed the organization characteristics should be, which was explained in the survey as PREFERRED. A 5-Point-Likert-scale for the competing values framework has been commonly used in recent organizational culture analyses in the construction sector (e.g. Oney-Yazıcı, Giritli, Topcu-Oraz, and Acar (2007); Willar, Trigunarsyah, and Coffey (2016); Zhang and Liu (2006); Koh and Low (2009)), and thus it is seen as a reliable scale to use in this study. The original OCAI questionnaire uses a response scale in which a respondent divides 100 points among the four typological alternatives. This is known as an ipsative rating scale. (K. S. Q. Cameron, Robert E. , 2011). The ipsative response scale does not give independent responses and the resulting scores are always related to each other. Using the 5 point Likert scale resolves the subjectivity, by allowing each of the responses to be independent (Teravainen, Junnonen, & Ali-Loytty, 2018).

Table 1: Construct Table

	Conceptual Model	Instrument	Target Population Sampled	Analytic Tools	Qualitative or Quantitative	Number of Questions	Validated Tool	Scale
1	Team Culture Cameron (2011)	Survey; Interview; Participant Oberservation	100 Conceptual Design 100 Quality	Organizational Culture Assessment Instrument (OCAI); Atlas.ti; Wordij	Quantitative; Qualitative	24	Yes	100 Points per dimension
2	Shared Meaning	Text Analysis; Interview; Participant Observation	30 Conceptual Design 30 Quality	Wordij; Atlas.ti	Qualitative; Quantitative	N/A	N/A	N/A
3	Information Exchange Subramaniam and Youndt (2005)	Survey; Participant Observation	100 Conceptual Design 100 Quality	Wordij; Atlas.ti	Quantitative; Qualitative	4	Yes	7 -Point Scale 1=To a very slight extent 7=To a very large extent
4	Network Structure Gloor (2008) and Interdepartmental Interactions Jaworski and Kohli (1993)	Email Analysis	10 Conceptual Design* 10 Quality*	Condor; Wordij; Atlas.ti	Quantitative; Qualitative	N/A	N/A	Betweeness Centrality (Low, High) Contribution Index (-1, 0, 1) Density (High, Low)
		Survey; Participant Observation	100 Conceptual Design 100 Quality	Wordij; Atlas.ti	Quantitative; Qualitative	14	Yes	5-Point Scale 1=Strongly Disagree 5=Strongly Agree
5	Quality Performance Menon, Jaworski et al. (1997)	Survey	100 Conceptual Design 100 Quality	N/A	Quantitative	3	Yes	5-Point Scale 1=Poor 5=Excellent
6	Advanced Product Design Performance Miranda Silva, G., et al. (2013)	Survey	100 Conceptual Design 100 Quality	N/A	Quantitative	6	Yes	7-Point Scale 1=Strongly Disagree 7=Strongly Agree

*Email analysis must be approved by Human Resources, there is some risk that HR will not approve an email analysis

Figure 4: Competing Values Framework Quadrants



Shared Meaning

Shared meaning was assessed qualitatively. Each survey participant was asked to write down the definition of quality and the definition of innovation. The definitions were compared and analyzed using WORDij, LIWC, and Atlas.ti. As previously mentioned, WORDij captures the relationships among words within the message to establish a network perspective. The structural map of the semantic networks was created using WORDij and is illustrated for conceptual design engineers, quality engineers, and those that associated with both teams in Chapter 5. This analysis enabled the statistical comparison of the semantic networks for the three groups to measure how similar or different they are from one another. LIWC was used to assess the positivity index of the three groups: advanced product design, quality, and the hybrid group that associated with both advanced product design and quality.

Survey results were coded and analyzed in Atlas.ti to examine shared meaning from the firm's teams.

Information Exchange

Information exchange was assessed quantitatively using four items drawn from Subramaniam and Youndt (2005). "Information is communicated," "We share information," "We exchange ideas with employees from different areas," and "We are encouraged to share our expertise." All questions contained a seven-point Likert scale ranging from 1 (to a very slight extent) to 7 (to a very large extent). Participant observation of team meetings and other interaction settings yielded information about how information exchange takes place.

Network Structure

The original research design included the element of network structure. Analysis of the conceptual design team and quality team networks were to use a Convergent Parallel Mixed Methods approach where both qualitative data and quantitative data would have been collected, analyzed separately, and then the results compared separately to see if the findings confirm or disconfirm each other. A network analysis tool was planned to be used to measure the connectedness of the conceptual design and quality teams upon approval from the automotive firm, and using the framework created by Peter Gloor (2008), the computer logs of the teams were to be mined using archived emails to trace the emergence of Collaborative Innovation Networks (COINs). During the time of this research, the firm was going through a major organizational change. Participants that were originally aligned to participate in the study withdrew based on the unknowns relative to the organization. Therefore, this element of the original research design is not assessed.

Interdepartmental Interactions

To assess interdepartmental interactions the study leveraged the measurement instrument of Jaworski and Kohli (1993). The constructs of interdepartmental connectedness and interdepartmental conflict were measured using seven items each. The conflict items pertain to the extent that the goals of the different teams are incompatible. The connectedness items assess notions of the extent to which members of the conceptual design and quality teams are networked to various levels of hierarchy in the opposite team. Items for each construct will be scored on a five-point scale ranging from 1 (strongly disagree) to 5 (strongly agree).

The results of the survey were used in assessing the conceptual design team and quality team organizational connectedness. The quantitative results of this analysis will be used to evaluate the conceptual model.

Product Quality Performance

Three items were used to ask participants for their assessment of the overall quality of the firm's products and services using measures from Menon et al. (1997). Items reflect an evaluation of the quality of products as well as how they compare with the firm's competitor offerings. These items were scored using a five-point scale, ranging from 1 (poor) to 5 (excellent).

Product Innovation Performance

Product innovation performance measures used the construct built by Silva (2013) for measuring product innovation on the basis of several criteria used in previous empirical studies of innovation. Product innovation is concerned with creating something new or generating new ideas that are reflected in the changes of the end product or service offered by the firm (Prajogo & Sohal, 2006). The items for product innovation performance use a seven-point Likert scale that represents

a range of attitudes from 1 (strongly disagree) to 7 (strongly agree). The operational items to measure study constructs can be found in Appendix E.

Structural Equation Modeling (SEM) will be used to analyze the survey data for the quantitative portion of this study. SEM is a statistical methodology that takes a confirmatory or hypothesis-testing approach to the analysis of structural theory bearing on some phenomenon (Byrne, 2013). For this study, it is important to formulate two of the propositions into hypotheses for testing using a SEM model approach. To that end, Propositions 4a and 4b are formulated into the following hypotheses:

Hypothesis 4a: The relationship between conflict and advanced product design performance is stronger for the advanced product design group.

Hypothesis 4b: The relationship between conflict and quality performance is stronger for the quality group.

Hypothesis 4c: The relationship between connectedness and advanced product design performance is stronger for the advanced product design group.

Hypothesis 4d: The relationship between connectedness and quality performance is stronger for the quality group.

Institutional Review Board (IRB) approval was obtained from Wayne State University's Division of Research to conduct research with human subjects. The original approval and extension forms are provided in Appendix B.

CHAPTER 5: QUALITATIVE RESEARCH RESULTS

The presentation of the research results for this study reflect the mixed methods research design in which the qualitative study, conducted first, informed the quantitative study. Therefore, the chapter starts with the qualitative research results and then transitions to the quantitative research results in Chapter 6.

The interviews of the firm's 20 executives were performed first during the summer of 2018, prior to the organizational changes mentioned in Chapter 4. Six of the interview participants are no longer with the company as a result of the organizational changes. The survey was issued in the summer of 2019, from July 9 to July 31 to more than 4,900 of the firm's employees in three organizations: research and advanced engineering, product development, and quality. The survey was issued after the organizational changes were complete to minimize bias in the survey that would be associated with the organizational changes. The sections that follow provide additional findings about the interview and survey demographics.

Interview: Sample Demographics

In this study the unit of analysis was a single Fortune 50 firm. The interviewees were chosen based on their current or prior roles in one of two areas: advanced product design, quality, or both, which is also be referred to as hybrid. The original list was generated based on those leaders with whom this researcher had a prior working relationship during employment at the firm. The list was revised during the interview process based on the recommendation of leaders from the original list consistent with a snowball sampling procedure. Those interviewed represented various categories. The first category was that of the leadership level at the firm. The leadership levels of those interviewed include vice president, director, chief engineer, and manager, representing four different leadership levels at the firm. Based on this researcher's experience at

the firm, leadership levels (L) range from level 6, which is an entry level leader, to corporate officer leadership level. The leadership levels are hierarchically ordered from L6 (lowest) to L1 (highest). The leadership levels may not correspond directly to leadership title, so for this study, the leadership levels were grouped to see if there were any trends that surfaced for the different categories. Managerial levels ranging from L6 to L4 were binned to the category called manager. This category only included the responses from L4 level managers. No L6 or L5 level leaders were interviewed. Chief engineers are mainly L3 level leaders, so this category was called chief engineers. Directors can range from L4 to L2 depending on their role in the firm. For this study, only directors at the L2 level were part of the interview sample, and they were binned to the director category. Vice presidents, at the L1+ level, were all binned into one category called vice president. The demographics of the participants is shown in Table 2.

Table 2: Interview Category Details

Category				
	Manager	Chief Engineer	Director	Vice President
Count	3	3	9	5
Percentage	15%	15%	45%	25%

Interview Results

As mentioned in Chapter 4, the transcribed interviews were analyzed using three tools; WORDij, LIWC, and Atlas.ti[15]. Various functions within each of the tools were used to assess the interviewees' responses to the interview questions (See Appendix C). Each interview was

[15] ATLAS.ti is a registered trademark of ATLAS.ti Scientific Software Development GmbH (2019), (https://atlasti.com)

analyzed individually and collectively in the respective leadership categories or groups. The sections highlight the results for each leadership level category. First, the analysis of the managerial level will be provided, followed by the results for the chief engineers, directors, then vice presidents. This section will end with a discussion of all the findings.

Manager Analysis

Once all of the transcriptions were converted from Word files to .txt files, the functions within WORDij were initiated. WordLink was run with the .txt file that contained the transcriptions of all the interviews with managers. The results show that the word "quality" was the most used word among the managers who were interviewed. Table 3 shows the top 40 words used by managers.

Table 3: Interview Most Frequent Words - Manager

WORD	FREQUENCY
quality	74
think	59
not	41
innovation	39
new	22
time	22
things	22
deliver	21
customer	19
ford	18
really	18
people	18
culture	18
work	17
good	16
way	16
make	14
lot	14
software	14
trying	14
dont	14
youre	13
strategy	13
definition	12
features	11
model	11
need	11
role	10
theyre	10
weve	10
product	9
right	9
process	9
corporate	9
experience	9
design	9
job	8
kind	8
working	8

The fact that the word "quality" is used almost two times more than the word "innovation" provides some insight into what managers believe is most important at the firm. Another fact to note is that the word "quality" was also used more than four times more than the word "customer", and based on the literature, customer satisfaction is linked closely to the quality of a product (Kim,

Kumar, & Kumar, 2012). Other key words to notice out of the list of 172 words that were mentioned more than three times in this group are "time, ford, people, and culture." These words formed the basis for the subsequent analysis of the open-ended survey questions.

The word pairs and their associated frequencies for all managers were also computed. The two sets of words that were most used and connected are "think quality" and "think strategy". These word pair combinations provide additional insight about managerial thinking. Paired with "Think" they use the words "quality and "strategy" more often than "innovation" and "culture". Table 4 shows the results of the word pair frequencies for managers. The four WORDij modules, OptiComm, VISij, QAPnet, and Z-Utilities, provide more insight into what these word and word pair frequencies mean.

Table 4: Interview Word Pair Frequency - Managers

WORD 1	WORD 2	FREQUENCY
think	quality	12
think	strategy	11
think	corporate	8
innovation	quality	8
corporate	strategy	8
deliver	quality	7
think	innovation	7
strategy	innovation	7
think	culture	6
definition	quality	6
deliver	innovation	5
think	good	5
model	quality	5
definition	innovation	5
initial	quality	5
describe	role	4
quality	innovation	4
quality	important	4
quality	simultaneou	4
deliver	new	4
deliver	stuff	4
deliver	simultaneou	4
new	content	4
think	really	4
think	changing	4
current	quality	4
current	model	4
model	based	4
good	job	4
innovation	new	4
innovation	simultaneou	4
corporate	quality	4
corporate	innovation	4
strategy	quality	4
achieved	together	4
describe	ford	3
role	ford	3
not	job	3
not	title	3
not	quality	3

OptiComm

The OptiComm module was initiated using the .wtg and .ptg files which were created when the WordLink module was run. The OptiComm module provided insight into the linkage of key words from the interviews for all managers by generating an optimal semantic path from a seed

word to a target word based on the actual words in a given text. The purpose of OptiComm is to provide the user with a set of messages designed to find a semantic path that links two words in three ways: first, a novel or innovative path where the strings have low average pair frequency; second, a set of messages to reinforce an existing message when the strings have a high average pair frequency; and third a set of messages designed to move two words further apart by linking a seed word to a remote target on the periphery of the semantic network.

For this study, it was important to understand the distance between the words "innovation", which was the seed word, and "quality" which was the target word and their average pair frequency. Other important parameters that were needed for the analysis were the maximum number of words in a word string, and the desired number of strings in the output. WORDij presets the analysis with parameters of five as maximum number of words in a string, and 16 as the desired number of strings in the output. The initial analysis was run with the standard drop list and the minimum words and word pair frequencies equal to a parameter of 3 with the OptiComm preset values; if needed, adjustments would be made to refine the parameters after completion of the initial analysis.

There are two critical parts of the OptiComm output: the distance[16], which is the first column and is a measure of the centrality of the string in the aggregate semantic network, and the average pair frequency, which is the second column. The results of the OptiComm analysis of managerial interviews show there was a distance of 0.125 (close) between the words "innovation" and "quality", with an average pair frequency of 8 (high). The default Wordlink and OptiCommanalysis settings showed that there were no other words in between these two words or that connected these words together. This finding means that managers highly associate

[16] OptiComm distance is calculated as 1/pair frequency.

"innovation" and "quality." There are no alternative semantic paths between the seed and the target words.

A similar outcome resulted from the analysis being run with the words in reverse order, with "quality" as the seed word and "innovation" as the target word. Again, there were no words in the semantic path between the seed and target words. However, the average pair frequency went down from 8 to 6. Having no words between the words innovation and quality or quality and innovation was likely an artifact of using the default drop list and having the minimum number of words and word pairs set to 3.

In order to further refine the OptiComm analysis for the interview with all managers, the initial WordLink run that created the files used by the OptiComm module, was re-run without the default drop list and the minimum parameter word and word pair frequencies was reduced from 3 to 1. The prior OptiComm result only gave one output string from innovation to quality and quality to innovation. The new WordLink analysis for all managers, which excluded the drop list and reduced the threshold of the minimum number of words from 3 to 1, showed that innovation and quality are linked to one another most often with the word "and". The average pair frequency between the seed and target word connecting through the word "the" was 13, and connecting through the word "and" was 10; these had the first and second highest word pair frequencies. Working with the word "and" seemed to make the most sense in understanding the connection between the seed word and the target word. The semantic network path is *innovation "and" quality* and for this study is interpreted to mean that managers do think and talk about both innovation and quality as paired concepts when it comes to advanced product designs. During the interview process, one of the interviewees quoted, *"To me, innovation is more the idea and quality*

is more the execution of the idea. There's no conflict there. They can exist together." (18:9) The output from the final OptiComm analysis is shown in Figure 5.

There was another semantic path that stood out in the analysis and that was the connection of the seed and target words made by the word "is". The analysis showed that the connection "innovation is quality" was in the top four of the highest average pair frequency for this analysis. This semantic path means that the managers believe innovation and quality are synonymous, and that there shouldn't be a difference between the two words. In sum, this path suggests that reinforcing messages to employees are: innovation and quality go together; and innovation is quality.

The interview process introduced some good feedback from the managers relative the intersection of innovation and quality. In response to the question, "What is your definition of innovation?", one of the interviewees stated *"Creating something that is unique or better or doing something like a process in a different and better fashion and better could be faster, with higher quality of events, could be cheaper." (18:3)* The fact that this interviewee used the word "quality" in the definition of innovation suggests that innovation "is" quality.

Figure 5: OptiComm Output - Managers[17]

[Distance] path (Average pair frequency)

Strings with low average pair frequency:
[1.5000] innovation -> have -> quality (1.5000)
[1.5000] innovation -> with -> quality (1.5000)
[2.0000] innovation -> a -> quality (1.0000)
[2.0000] innovation -> work -> quality (1.0000)

Strings with high average pair frequency:
[0.1429] innovation -> quality (7.0000)
[0.2000] innovation -> and -> quality (10.0000)
[0.2476] innovation -> the -> quality (13.0000)
[0.3429] innovation -> is -> quality (6.0000)

All paths
[0.1429] innovation -> quality (7.0000)
[0.2000] innovation -> and -> quality (10.0000)
[0.2476] innovation -> the -> quality (13.0000)
[0.3429] innovation -> is -> quality (6.0000)
[0.6667] innovation -> you -> quality (4.0000)
[1.1667] innovation -> to -> quality (3.5000)
[1.2500] innovation -> in -> quality (2.5000)
[1.2500] innovation -> strategy -> quality (2.5000)
[1.3333] innovation -> your -> quality (2.0000)
[1.3333] innovation -> culture -> quality (2.0000)
[1.3333] innovation -> can -> quality (2.0000)
[1.5000] innovation -> have -> quality (1.5000)
[1.5000] innovation -> with -> quality (1.5000)
[1.5000] innovation -> about -> quality (1.5000)
[1.5000] innovation -> not -> quality (1.5000)
[2.0000] innovation -> a -> quality (1.0000)
[2.0000] innovation -> work -> quality (1.0000)

"Quality is innovation" also showed up as an output of the analysis when the word "quality" is the seed word and "innovation" is the target word.

VISij - Manager Category

[17] OptiComm, traces all shortest paths between a seed word and a target word, both of which must be connected indirectly in the network.

OptiComm defaults to producing 5 word strings, which you can set to be a longer value. It also defaults to producing 16 messages of alternative shortest paths.

If you do not enter a target word it defaults to the most central word in the network.

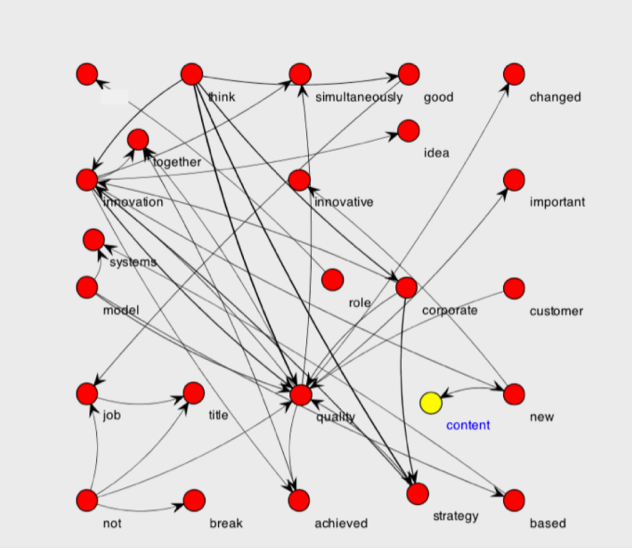
If you want to move two words closer together, and the concept is "innovative", it may be best to select the shortest path of low frequency, using the output labeled, "Strings with Low Average Pair Frequency," listed first in the output. Our lab experiments have shown this to be most effective. The theory is that while the words are central, they are attractive because their use is less frequent in the particular language community.

If you want to move two words closer together and reinforce an already strong connection, you may want to use the shortest strings of most frequent words, labeled "Strings with High Average Pair Frequency," which is listed second in the output. These words are more frequently used in the language community.

Source: Wordij Documentation Wordij At-a-Glance, p.2.

The next phase of this study included the use of VISij to get a visual representation of the semantic network for the managers. The tool allows the user to see the semantic network statically, or it can be shown as an animation from one static network to another. The output of VISij reveals a clear connection between the two words innovation and quality, as expected. The output provides additional insight into how the managers view the intersection of innovation and quality. Some of the noteworthy connections include the link from "innovation" to "new" then to "content" as well as the link from "innovation" to "new" and then to "innovative". The output from this portion of the analysis is shown in Figure 6.

Figure 6: VISij Output - Managers



This visual semantic network indicates that managers say products require new innovative content to be considered an innovation. Other noteworthy connections are those made between the words "model", "based", and "systems". This network suggests the managers are thinking about new and innovative processes like model-based systems engineering and, on a level closest to the work being done. This is what one manager had to say, *"There is an effort to use a model-based systems approach when it comes to our software driven systems. If you can use a model-based systems engineering approach it will help make sure your requirements are robust and will*

lead to functional models to help create software… this is a new animal that needs to be addressed".

QAPnet - Manager Category

The next phase of the analysis was conducted using the QAPnet module in WORDij, which enables the comparison of semantic networks computing correlations between two texts. As was previously mentioned, the QAPnet results can range from -1 to +1. A correlation of -1 means that the texts are perfectly negatively correlated. In other words, the word pairs are completely different. The texts share common words, but the word pairing is different. For example, the word pair "quality warranty" vs "quality innovation. The word pairs have the common word "quality" but each text pairs the word "quality" with a different second word. A QAPNet correlation of "0" means the texts do not have any word pairs in common. A +1 correlation means the word pairs are completely identical.

The full QAPnet output for all twenty interviews can be found in Table 5. The QAPnet results for all of the interviews ranged from -0.908 to -0.484, with an average of -0.726 and a median of -0.7315.

Table 5: QAPnet Results for All Interviews

	Interview Code Number																			
	8	10	7	15	17	25	27	28	12	13	18	32	36	15	16	29	38	21	31	30
8		-0.868	-0.639	-0.665	-0.773	-0.7	-0.792	-0.729	-0.558	-0.706	-0.82	-0.785	-0.818	-0.777	-0.694	-0.693	-0.764	-0.842	-0.731	-0.719
10			-0.709	-0.695	-0.83	-0.846	-0.885	-0.875	-0.603	-0.849	-0.901	-0.839	-0.886	-0.908	-0.823	-0.839	-0.801	-0.863	-0.846	-0.825
7				-0.721	-0.694	-0.566	-0.651	-0.61	-0.587	-0.562	-0.673	-0.629	-0.62	-0.574	-0.648	-0.622	-0.73	-0.786	-0.665	-0.56
15					-0.731	-0.616	-0.67	-0.636	-0.702	-0.609	-0.684	-0.66	-0.662	-0.579	-0.676	-0.65	-0.787	-0.795	-0.69	-0.632
17						-0.731	-0.773	-0.766	-0.608	-0.722	-0.811	-0.756	-0.773	-0.74	-0.75	-0.712	-0.756	-0.824	-0.755	-0.724
25							-0.744	-0.661	-0.534	-0.633	-0.778	-0.724	-0.78	-0.732	-0.645	-0.642	-0.728	-0.816	-0.681	-0.661
27								-0.726	-0.555	-0.749	-0.836	-0.754	-0.791	-0.827	-0.738	-0.724	-0.777	-0.846	-0.766	-0.726
28									-0.484	-0.688	-0.784	-0.753	-0.794	-0.77	-0.713	-0.694	-0.744	-0.823	-0.719	-0.694
12										-0.508	-0.576	-0.558	-0.575	-0.49	-0.582	-0.55	-0.633	-0.691	-0.584	-0.533
13											-0.778	-0.741	-0.779	-0.741	-0.642	-0.635	-0.703	-0.806	-0.679	-0.661
18												-0.827	-0.851	-0.845	-0.802	-0.789	-0.797	-0.855	-0.8	-0.772
32													-0.782	-0.788	-0.733	-0.735	-0.755	-0.82	-0.77	-0.704
36														-0.828	-0.785	-0.781	-0.771	-0.838	-0.8	-0.715
15															-0.734	-0.74	-0.694	-0.809	-0.719	-0.738
16																-0.637	-0.765	-0.841	-0.703	-0.678
29																	-0.712	-0.825	-0.671	-0.654
38																		-0.82	-0.755	-0.72
21																			-0.832	-0.814
31																				-0.691
30																				

The results of the QAPnet analysis for all managers is shown in Table 6.

Table 6: QAPnet Results - Managers

	Interview Code Number		
	8	7	31
8		-0.639	-0.731
7			-0.665
31			

Given the average and median of the total QAPnet results, it can be seen that participants 7, 8 and 31 are highly negatively correlated. This suggests the interview responses were not similar based on the content of the interviews.

Z-Utilities - Manager Category

The Z-Utilities module was run to determine what words and word pairs are the same or significantly different in between two interviews or sets of interviews. The Z-Utilities was run to compare the Z-Scores for the words and word pairs in the managers' interviewers with all of the other leadership categories. When comparing interviews in the managers category to the interviews in the chief category, words that surfaced more for managers than chiefs were "deliver" (21 versus

5) and "delivering" (6 versus 0) with significant z-scores of 5.01 and 3.339, respectively[18]. This insight suggests the managers were more concerned with delivery of products than those in the chief category. This result corroborates the prior finding that managers are more concerned with what's happening at the working level. When comparing word pairs in the interviews in the managers category to the interviews in the chief category, word pairs that surfaced more for managers than chiefs were "think strategy" (11 versus 6; z-score 1.88), "time think" (3 versus 0; z-score 2.022), and "think changing" (4 versus 0; z-score 2.337). Both managers and chiefs mention innovation and quality about the same number of times (z-score 3.16 and 4.27, respectively), but quality is mentioned twice as often as innovation in both cases. The word "customer" was also mentioned in both sets of interviews, with managers mentioning customers more often than the chief engineers; 19 times for managers versus 12 times for chief engineers with a z-score of 3.18, which is significant.

When comparing the words in interviews of the managers with the interviews of the directors, the following was found in the data. Words that managers mentioned more often than directors include "deliver" (21 versus 17; z-score 5.09) and "features" (11 versus 9; z-score 3.67), again showing that managers are thinking about topics relevant to them at the working level, versus the directors who may be thinking at a more strategic level. The directors' interviews have a higher frequency of the words "people" (18 versus 82, z-score -0.852, which is noteworthy but not statistically significant) and "right" (9 versus 90, z-score -3.02, which is significant). Directors

[18] The Z-test cannot produce a value when one of the pairs has a frequency of zero, so Wordij enters a very small constant to replace zero.
The critical z value for two proportions are:
$p < .05$ is + /- 1.64,
$p < .01$ is +/- 2.389
$p < .001$ is +/- 3.5

Source: Wordij documentation Wordij At-a-Glance, p.3.

talked a lot about "people" who work at the company and how "people" make things work, as well as "people" being the customer. Some of the quotations from directors include, *"I think it's about having good people- the right kind of people- the right kind of environment with the right kind of culture, 'cause culture nurtures it."* (7:46) and *"...do the right thing to satisfy customers and that's when innovations come on".* (8:20) This finding suggests the directors are strategically thinking about the people of the company, what it would take to deliver quality and innovation simultaneously, and that satisfying customers is the way to improve innovation performance; managers are thinking more tactically about topics like delivery. When analyzing the word pair frequencies, "deliver new" and "deliver stuff" were said four times versus zero for directors with a z-score of 3.86. Directors mentioned "corporate strategy" and "innovation quality" more often than managers said these word pairs with a z-score of 0.657, which is not significant but noteworthy.

Comparing the word frequency output of managers and vice presidents showed some similarities when compared with the analyses of managers with the chiefs and directors, but there were also some differences. The word "quality" was mentioned one and a half times as often by the managers than the vice presidents with a z-score of 1.19. Managers mentioned "people" twice as often than the vice presidents, and "deliver" more often than the vice presidents with z-scores of 1.23 and 0.04, respectively. On the other hand, the vice presidents mentioned "product" twice as often as the managers, and "strategy" more often with z-scores of -1.73 and -1.47, respectively. The two groups mentioned "customer" about the same amount of times (z-score, -0.955). The word pair analysis showed managers mentioned "think quality" twice as often as the vice presidents with a z-score of 1.85. The vice presidents mentioned "deliver quality" more often than the managers with a z-score of -0.610. The vice presidents also mentioned "take risks", where this

word pair did not show up at all in the data from the manager interviews. The managers word pair analysis shows the managers mentioning "think changing" four times, which is the response to the question "what culture do you believe is necessary to deliver both innovation and quality, simultaneously; this finding was not identified in the word pairs for the other leader categories.

LIWC - Manager Category

LIWC was run for all the managers' interviews. A positivity index was created by dividing the percentage of words categorized as positive emotion by the percentage of words categorized as negative emotion in the LIWC dictionary. The matrix that contains the positivity index for the LICW analysis for all managers is show in Table 7. The average positivity index falls as the managerial level increases.

Table 7: LIWC Positivity Index - All Managers

compare	interrog	number	quant	affect	posemo	negemo	Positivity Index	anx
2.75	1.95	1.46	2.56	3.89	3.35	0.50	6.70	0.19

Table 8: LIWC Positivity Scores - All Leadership Groups

	LIWC Positivity Index
Manager	6.7
Chief	3.79
Director	2.3
VP	1.85

The managers were very positive with a score of 6.70, which was the highest positivity score of all of the leadership category groups (see Table 8). All of the manager's interview positivity scores were above the average positivity score of 2.8 for all interviews as seen in Table 9, with the highest positivity score of 13.1 coming from one of the directors that identifies with the conceptual design group.

Table 9: LIWC Positivity Scores - All Participants

Rank	Positivity Index	Group
1	13.1	Director
2	11.59	Manager
3	5.71	Director
4	4.79	Chief
5	4.77	Director
6	3.68	Manager
7	3.67	Manager
8	3.52	Chief
9	3.26	VP
10	3.05	Director
Average PI	2.8	
11	2.8	VP
12	2.4	Director
13	2.09	Director
14	1.98	Director
15	1.92	VP
16	1.57	Chief
17	1.43	VP
18	1.29	Director
19	1.21	Director
20	1	VP
Median	2.925	

The second highest positivity score, 11.59, was for one of the managers from the quality group. This interview was recorded, where the other two interviews were scribed and had positivity scores of 3.68 and 3.67, which could have made a difference in the positivity scores. Overall, these positivity scores suggest the managers have a positive outlook on the intersection of quality and innovation. The WORDij analysis and the quotations from the managers are positive and indicate the managers believe quality and innovation can be achieved together. The participant with the highest positivity score commented as follows, *"they can be achieved together by having the right leadership that understands that creating a both-and situation and not an either-or situation that relates to quality versus innovation [is important]".* (14:13, 14:25) The other managers agree that the intersection of innovation and quality is possible

with a few changes, including listening more, being open to new ideas, and embracing a culture that allows risk taking.

Of the three managers that were included in this study, two had prior experiences in both an advanced product design capacity and in a quality capacity, which is considered hybrid. The third manager only had experience in a quality role at various general and leadership levels. When comparing the positivity index for those in the hybrid role versus the one in the quality role, those in the hybrid role had a higher positivity index than the one manager in the quality role; this was both individually and on average. However, one of the hybrid manager's positivity score was comparable at 3.68 versus the quality manager's positivity score of 3.67.

Other notable items include the highest positivity score among all interviews was from one of the directors and was 2.29 times higher than the next director's positivity score of 5.71. The positivity score for all of participants that identified with the hybrid group (those that had experience in both conceptual design and in quality), had a higher positivity index average that those that identified with conceptual design or quality independently (see Table 10). Another noteworthy finding is that the positivity score for those interviews that were recorded at 4.503 was higher that the positivity scores for the interviews that were scribed at 3.42.

Table 10: LIWC Positivity Score - Organization Group

	Positivity Index Avg
Concept Design	3.49
Hybrid	4.29
Quality	3.35

Table 11: LIWC Positivity Scores by Transcription Type

	Positivity Index Avg
Recorded	4.503
Scribed	3.42

Atlas.ti Results

Analysis of the interview transcriptions was conducted using the qualitative data analysis program Atlas.ti. All of the transcribed interviews were imported into Atlas.ti and each document was coded around the topics of interest including, quality, innovation, culture, and teams. A table of the codes, sub-codes, and their frequencies is shown in Table 12.

The following sections provide an overview of the conceptual networks that were created by relating the codes to one another. The code networks provide an overview of the thinking among organizational leaders about how quality and innovation are related to each other and to culture and how teams should work to achieve both quality and innovation.

Table 12: Atlas.ti Code and Sub-code Frequencies

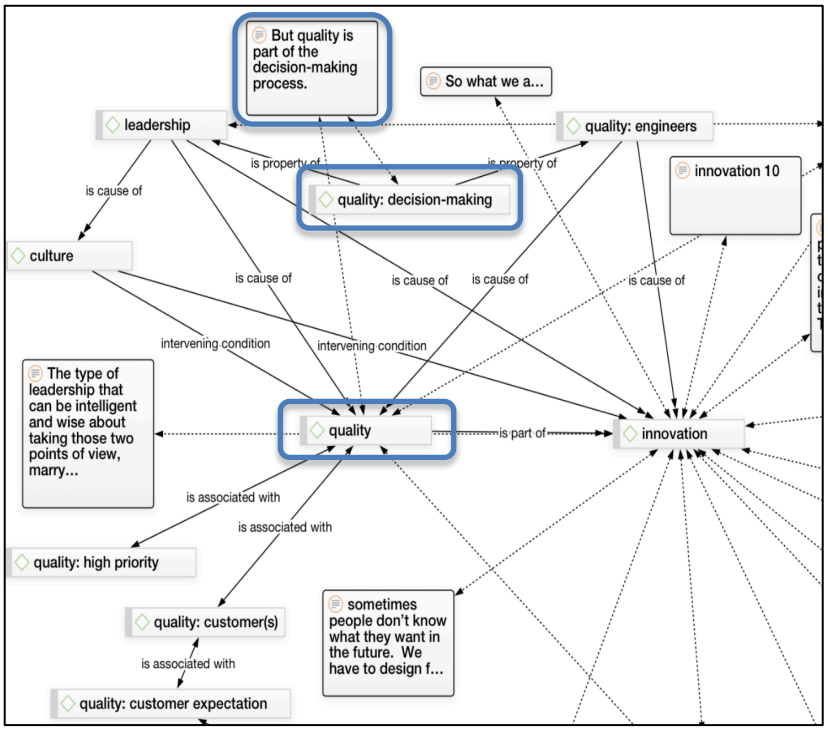
culture	53
customer	30
Inhibitors	37
Innovation	119
innovation and quality	37
innovation strategy	11
leadership	20
Quality	101
quality strategy	19
risks	29
teams	21

Quality

The analysis began by creating a coding network for “quality”. The code “quality” was put into the network manager function in Atlas.ti and the associated codes were also pulled into

the conceptual network using the Add Neighbors -> Codes function. The newly created code network introduces the node innovation, suggesting that innovation is connected to quality based on the coding. "Leadership" and "quality engineers" were also included in the network and associated with the codes "innovation" and "quality." Both the "leadership" node and the "quality engineer's" node were associated with determining the success or failure of quality and innovation. The code "Quality: decision making" also showed up as a part of the network and was directly linked to leadership and quality engineers. Following the creation of the network of codes, the quotes for the respective codes were entered using the Add Neighbors -> Quotes function. One quote that was added and associated with "quality: decision making" stated, "But quality is part of the decision-making process," (see Figure 7) which speaks to the fact that quality (and innovation), along with cost and other factors must be considered in the advanced product development process.

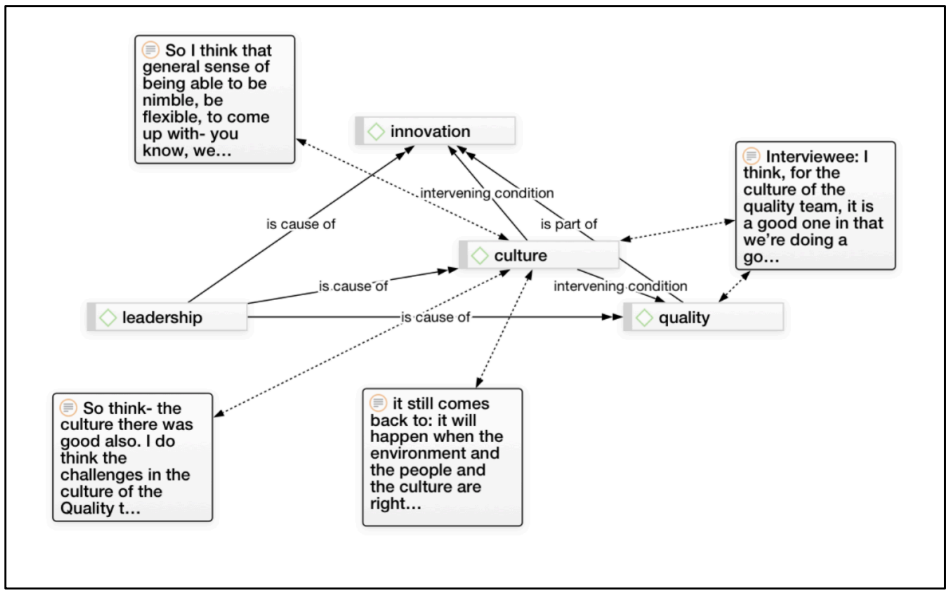
Figure 7: Atlas.ti Quality Network



Culture

Further assessment of this network highlights culture as an intervening condition for both quality and innovation; which is interpreted to mean culture determines the outcome either favorably or not of innovation and quality (Bell & Gluesing, Forthcoming). When reviewing the quotations associated with culture, the context that emerged was around having a nimble and flexible culture when it comes to ensuring that innovation and quality coexist. One of the quotes says, "… it still comes back to: it will happen when the environment and the people and the culture are right. It just happens." One of the interviewees talked about how the culture in the advanced product team they were a part of was a good one. However, the interview did not include questions about how type of culture could be created. The Atlas.ti network for culture can be seen in Figure 8.

Figure 8: Atlas.ti Culture Network

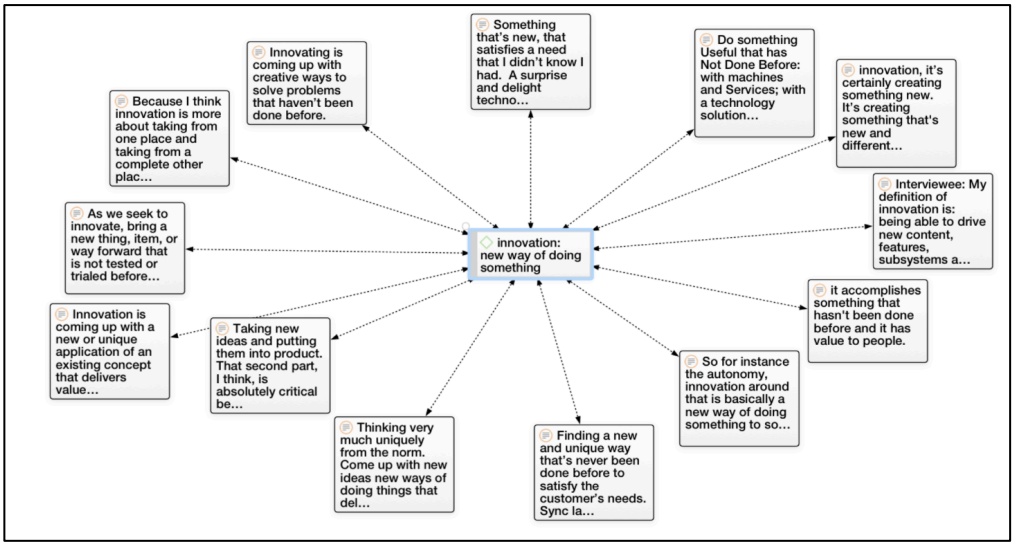


Innovation: A new Way of Doing Things

Other quotations that were imported with the Neighboring function were around corporate strategy and include the quote, "I believe our strategy around innovation is to encourage and foster

an environment that more employees can be more involved in innovation, so they have a better chance of creating new ideas, new technologies, new content, that can set us apart from our competition." This is one interviewee's view of the innovation landscape at the firm. This same interviewee goes on to explain their definition of innovation in direct response to the question, "What is your definition of innovation?" The interviewee stated that innovation is. "… being able to drive new content, features, subsystems and components to develop and drive the entities that I just mentioned to serve some customer in a unique way than what they have had before." The code network was elaborated, importing into the network the code "Innovation: doing something new." The introduction of this new code was supported by the quotes from four interviewees at the vice president level (33%), one at the manager level (8.3%), five at the director level (42%), and 2 at the chief level (16.7%). This definition of innovation is also supported in the literature in that "an innovation as "an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (Rogers, 2003, 2010). Figure 9provides the quotes that are associated with the code Innovation: new way of doing something.

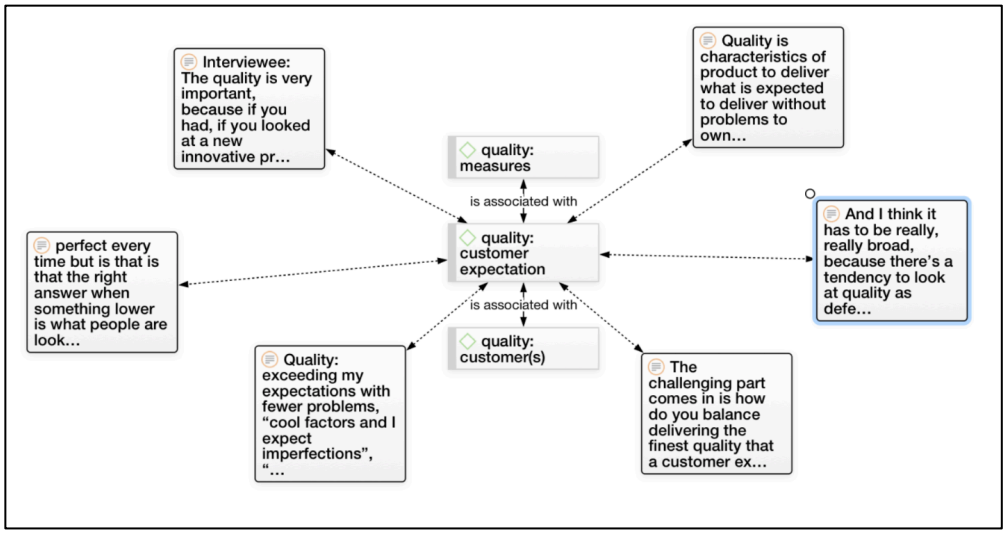
Figure 9: Atlas.ti Network Analysis for Innovation: New Way of Doing Something



Quality: Customer Expectation

Quality was a thematic code in building the code network. One sub-code emerged as a central in understanding the meaning of quality in the organization: “Quality: customer expectation”. There were a number of interviewees that talk of customer expectations in various ways. When the quotations associated with quality: customer expectation were extracted there were thirty quotations from sixteen interviewees. Of those, two were managers, three were chief engineers, seven were at the director level, and there were four VPs. VPs and Directors mentioned this topic multiple times, which indicates that customer expectation is a key area of focus: quality in the context of meeting or exceeding customer expectations. It is clear from the quotations that quality is defined by the customer. One of the interviewees mentioned the KANO model, saying "KANO Model describes it, surprise and delight, defects and warranty elimination.” The interviewee then goes on to say more about ensuring the customer can do things flawlessly. One interviewee explained it this way, "We really want to satisfy our customer…but there are a lot of ways to get there,” and that would include a culture of focusing on the customer, also substantially supported in the literature (Alotaibi et al.; Chandra, 1993; Dean & Evans, 1994; Gkana, 2014; Kanji, 1996; Long et al., 2015; Ooi et al., 2012; Prajogo & Hong, 2008; Tang, 1998; Zehir et al., 2012). The next section will delve more deeply into the analysis around a culture of focusing on the customer.

Figure 10: Atlas.ti Network - Quality: Customer Satisfaction

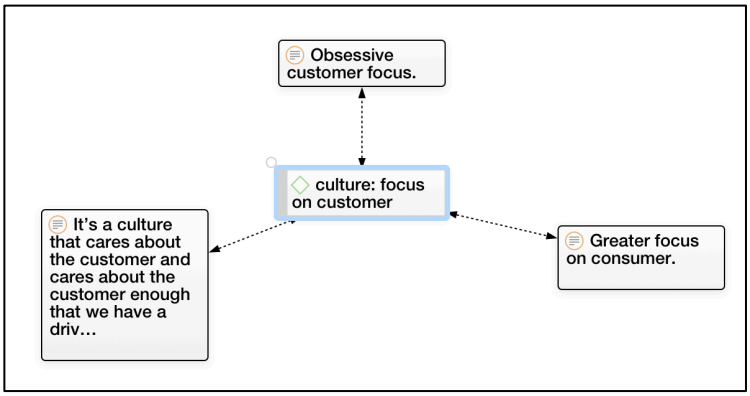


Culture: Focus on Customer

A code network was created and centered around "culture". This new network introduced other connections to the concepts of innovation, quality, and leadership. "Group culture" and "Culture: focus on customer" were two additional codes introduced into the network. Nineteen quotes from every leadership level were associated with "Culture: focus on the customer and were visualized in the network view. In response to the question "What culture do you believe is necessary to deliver both innovation and quality simultaneously?" one interviewee said, "Obsessive customer focus". This same interviewee went on to say that, "we spend most of our time being product focused and look to marketing to handle understanding the customer". It was also said by one of the interviewees that other companies good in quality and innovation don't compartmentalize and that all teams [in the company] innovate. One of the VP interviewees talked about one of their consumer electronics products going on to explain how the product was elegant and easy to use. It was mentioned this product "hit all cylinders". This quote led to another quote that said "[we] need to know the needs of our customers before they can even think about it". This interviewee goes on to say that innovation and quality can be achieved together when people are

under pressure. It was clear from the interviews that the leadership of the firm believes that the culture there should be a focus on the customer. Based on their own experiences, they know firsthand the power of customer satisfaction and how it can change the course of the company for both innovation and quality. Figure 11 is an illustration of the network around a culture of customer focus.

Figure 11: Atlas.ti Network for Culture: Focus on the Customer



Open-Ended Question Analysis

To supplement and broaden understanding of the meaning people in the organization have about quality and innovation, the survey included two open-ended questions: "Please provide in your own words the definition of QUALITY" and "Please provide in your own words the definition of INNOVATION". WORDij, LIWC, and Atlas.ti were used to analyze the responses to these questions. The analysis from these tools will be beneficial in determining whether Propositions 2a and 2b are supported.

WORDij Analysis

Definition of Innovation

The responses to the open-ended survey questions for the three groups, advanced product design (APD), quality, and hybrid were analyzed using the WordLink function in WORDij. The APD group responses to the definition of INNOVATION showed the words *new, innovation,* and

product were the most mentioned words in the response with a frequency of 74, 53, and 27 respectively (see Table 13). The word pair frequencies for the response to the same question were "innovation new", "new ideas", and "new product" with frequencies of 16, 10, and 8, respectively.

Table 13: Open Ended Question Word Frequency Details - Innovation

Hybrid		Quality		APD	
WORD	FREQUENCY	WORD	FREQUENCY	WORD	FREQUENCY
new	60	new	18	new	74
innovation	41	innovation	17	innovation	53
customer	25	not	17	product	27
product	24	customer	13	technology	26
customers	14	product	8	customer	26
not	13	need	6	not	23
technology	12	products	5	ideas	19
features	11	ideas	5	customers	18
process	10	people	4	way	18
way	10	creating	3	existing	18
existing	10	ways	3	solutions	15
creating	10	technology	3	products	14
products	9	technologies	3	cost	14
design	9	process	3	problem	13
things	8	surprise	3	creating	11
delivering	7	delight	3	solution	10
ideas	7	service	3	problems	10
innovative	7	providing	3	features	10
solutions	7	market	3	process	10
time	6	improve	2	function	10
experience	6	work	2	feature	9
market	6	continuous	2	development	8
need	6	knowledge	2	idea	8
want	6	move	2	experience	8

Table 14: Open Ended Question Word Pair Frequency Details - Innovation

Hybrid			Quality			APD		
WORD1	WORD2	FREQUENCY	WORD1	WORD2	FREQUENCY	WORD1	WORD2	FREQUENCY
innovation	new	15	innovation	new	5	innovation	new	16
new	features	8	innovation	not	4	new	ideas	10
new	ideas	7	product	service	3	new	product	8
creating	new	7	new	ways	3	new	way	8
new	technology	6	new	ideas	3	new	technology	7
product	new	6	customer	not	3	solutions	problems	6
innovation	product	5	surprise	delight	3	creating	new	6
new	customer	5	innovation	finding	2	innovation	solution	5
product	process	5	innovation	ways	2	innovation	equals	5
innovation	process	4	innovation	bring	2	new	not	5
new	product	4	innovation	providing	2	product	feature	4
new	existing	4	improve	product	2	innovation	customers	4
new	products	4	not	necessarily	2	innovation	solutions	4
new	solutions	4	not	high	2	innovation	not	4
products	customer	4	not	tech	2	innovation	creating	4
innovation	customers	3	not	consumer	2	new	products	4
innovation	creation	3	continuous	new	2	new	ways	4
customers	needs	3	new	product	2	new	idea	4
new	method	3	new	not	2	new	customer	4
new	idea	3	new	technology	2	customer	experience	4
new	unique	3	new	customer	2	finding	new	4
new	ways	3	new	deliver	2	customers	products	3
new	creative	3	finding	new	2	technology	new	3
delivering	new	3	finding	ways	2	technology	customer	3

The OptiComm results for the ADP group responses to the definition of innovation suggest that the word path for reinforcing the link between the words "innovation" and "quality" is:[19] [innovation -> new -> ideas -> products -> quality] as shown in Figure 12 because it has the highest average pair frequency of 7.25.

Figure 12: OptiComm Output APD Team, Definition of Innovation

[Distance] path (Average pair frequency)

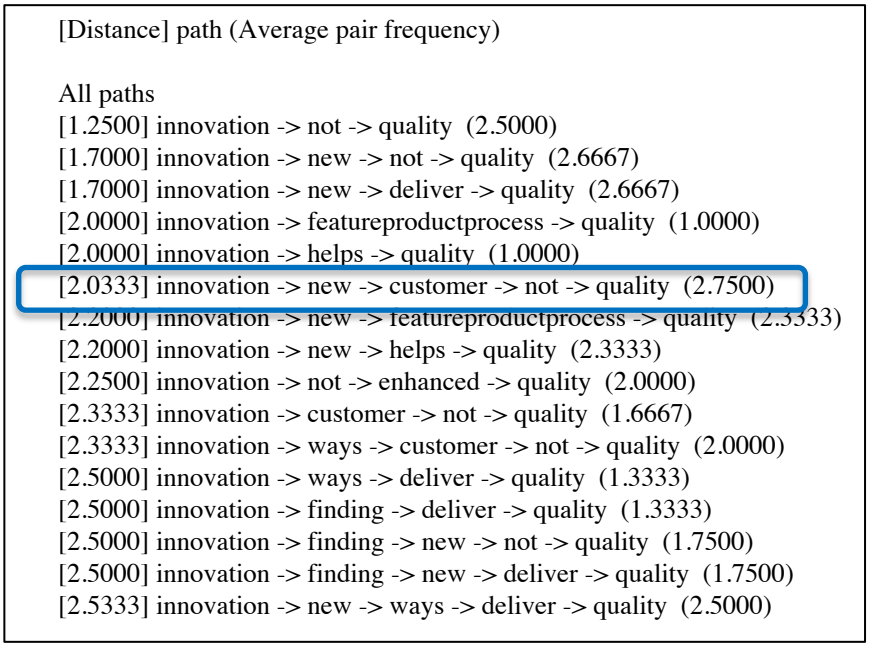
All paths
[1.0000] innovation -> quality (1.0000)
[1.0625] innovation -> new -> improved -> quality (6.6667)
[1.3125] innovation -> new -> ways -> quality (7.0000)
[1.3125] innovation -> new -> products -> quality (7.0000)
[1.3958] innovation -> new -> function -> quality (6.6667)
[1.4167] innovation -> creating -> new -> improved -> quality (3.5000)
[1.5000] innovation -> improved -> quality (1.5000)
[1.5833] innovation -> customers -> products -> quality (2.6667)
[1.6625] innovation -> new -> ideas -> products -> quality (7.2500)
[1.6667] innovation -> creating -> new -> ways -> quality (3.7500)
[1.6667] innovation -> creating -> new -> products -> quality (3.7500)
[1.6667] innovation -> product -> new -> improved -> quality (2.5000)
[1.7054] innovation -> new -> technology -> improved -> quality (6.5000)
[1.7054] innovation -> new -> technology -> right -> quality (6.5000)
[1.7500] innovation -> creating -> new -> function -> quality (3.5000)
[1.7500] innovation -> solutions -> improved -> quality (2.3333)
[1.7500] innovation -> not -> products -> quality (2.3333)
[1.7500] innovation -> solutions -> provide -> improved -> quality (2.5000)
[1.7500] innovation -> customers -> new -> improved -> quality (2.5000)

This would suggest the APD team believes the path from innovation to quality is through the introduction of new ideas in the company's products. Some notable quotes from the advanced product design team relative to innovation include *"Innovation is always looking for ways to improve the quality of a product as well as the benefit to the user through emerging technologies or new applications of existing technologies"* and *"Innovation is finding new solutions for problems that provide improved function, improved quality or lower cost."*

[19] For this analysis the seed word was "innovation" and the target word "quality".

The Quality group responses to the definition of INNOVATION showed that the words *new, innovation, not, and customer* (*not* and *customer* had the same frequency) were the most mentioned words in the response with a frequency of 18, 17, and 13, respectively. The word pair frequencies for the response to the same question were *"innovation new", "innovation not"* and *"product service",* with frequencies of 5, 4, and 3, respectively. These results indicate that the Quality group may believe that innovation requires new ways of doing things, including product service. The OptiComm and Atlas.ti details will give more insight into the details behind the *"innovation not"* word pair. The OptiComm results for the Quality group responses to the definition of innovation suggest that the word path for reinforcing the link between the words "innovation" and "quality" is:[20] [innovation -> new -> customer -> not -> quality] because it has the highest average pair frequency of 2.750 (see Figure 13) .

Figure 13: OptiComm Output Quality Team - Definition of Innovation

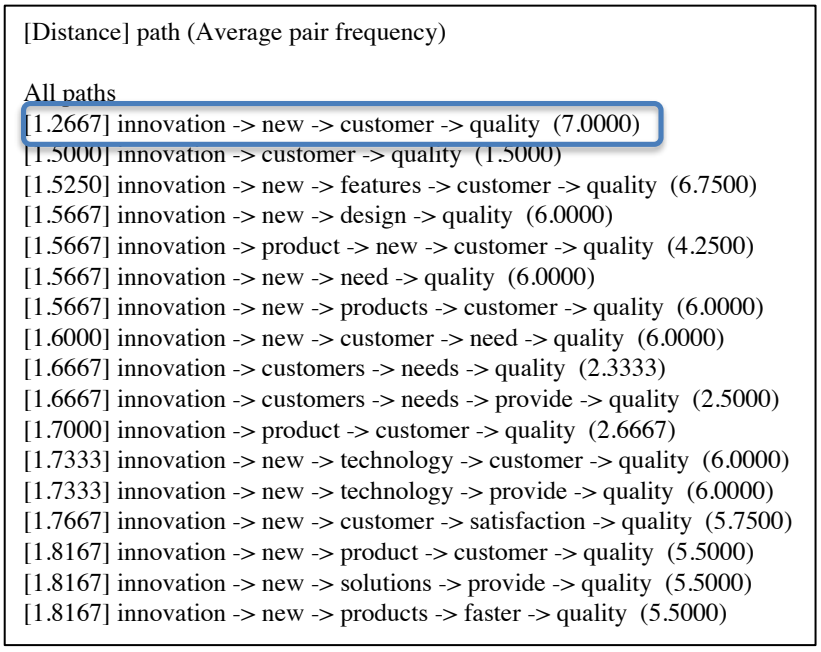


[20] For this analysis the seed word was "innovation" and the target word "quality".

This could be interpreted to mean that the quality group believes innovation is new to the customer but is not specifically for quality. There seem to be different views about the relationship of innovation and quality, which might also explain why there might be some high negative correlations in the QAPnet analysis of the interviews. Not everyone believes that innovation and quality are positively associated. Additional research into the meaning of the OptiComm output through the quotes from Atlas.ti provide interesting insights. Quotes that included the word "not" were mainly about what innovation is not as opposed to innovation not being linked to quality. Notable quotes include, *"a new solution that meets deliverables in a way not done before: enhanced quality, more efficient, improved metrics…"*, *"Innovation does not mean 'filing for a patent."*, and *"[Innovation is] developing something new and not done previously or in a manner different from what was done in the past."*

The Hybrid group responses to the definition of INNOVATION showed the words *new, innovation, customer, and product* were the most mentioned words in their response with frequencies of 60, 41, 25, and 24, respectively (Table 13). The word pair frequencies for the response to the same question were *"innovation new", "new features", and "new ideas"* with frequencies of 15, 8, and 7, respectively (Table 14). The OptiComm results for the Hybrid group responses to the definition of innovation suggest that the word path for reinforcing the link between the words "innovation" and "quality" is: [innovation -> new -> customer -> quality] because it has the highest average pair frequency of 7. See Figure 14.

Figure 14: OptiComm Output Hybrid Team - Definition of Innovation



[Distance] path (Average pair frequency)

All paths
[1.2667] innovation -> new -> customer -> quality (7.0000)
[1.5000] innovation -> customer -> quality (1.5000)
[1.5250] innovation -> new -> features -> customer -> quality (6.7500)
[1.5667] innovation -> new -> design -> quality (6.0000)
[1.5667] innovation -> product -> new -> customer -> quality (4.2500)
[1.5667] innovation -> new -> need -> quality (6.0000)
[1.5667] innovation -> new -> products -> customer -> quality (6.0000)
[1.6000] innovation -> new -> customer -> need -> quality (6.0000)
[1.6667] innovation -> customers -> needs -> quality (2.3333)
[1.6667] innovation -> customers -> needs -> provide -> quality (2.5000)
[1.7000] innovation -> product -> customer -> quality (2.6667)
[1.7333] innovation -> new -> technology -> customer -> quality (6.0000)
[1.7333] innovation -> new -> technology -> provide -> quality (6.0000)
[1.7667] innovation -> new -> customer -> satisfaction -> quality (5.7500)
[1.8167] innovation -> new -> product -> customer -> quality (5.5000)
[1.8167] innovation -> new -> solutions -> provide -> quality (5.5000)
[1.8167] innovation -> new -> products -> faster -> quality (5.5000)

This could be interpreted to mean innovation provides new products to the customers with quality. The Hybrid group appears to view innovation in a primarily positive relationship to quality. A few notable quotes from the Hybrid team relative to the connection between innovation and quality are, *"innovation pushes society forward through new technologies [to] deliver those products that increase customer satisfaction and need for a quality and fun experience"* and, *"Innovation is being the first to show customers new technology and advancements, and doing it right the first time".*

Definition of Quality

The APD group responses to the definition of QUALITY showed the words *quality, product, and customer* were the most mentioned words in the response with a frequency of 63, 55, and 41 respectively (see Table 15). The word pair frequencies for the response to the same question were *"quality product", "product customer", and "meets expectations"* with frequencies of 15, 8, and 7, respectively (see Table 16).

Table 15: Open Ended Question Word Frequency Details - Quality

Hybrid		Quality		APD	
WORD	FREQUENCY	WORD	FREQUENCY	WORD	FREQUENCY
quality	54	quality	24	quality	63
product	47	customer	20	product	55
customer	27	product	20	customer	41
customers	20	customers	11	expectations	24
not	14	products	9	life	19
life	13	delivering	7	customers	18
expectations	12	without	6	intended	17
design	11	defects	6	function	17
products	9	not	6	not	15
meet	9	expectations	6	meets	14
vehicle	9	experience	4	products	13
performance	8	want	4	time	13
excellence	8	service	4	no	13
satisfaction	7	meets	4	part	12
needs	7	vehicle	4	expected	11
time	7	consumers	4	meet	10
delivering	7	no	3	failure	9
meets	7	meet	3	reliability	9
measure	6	means	3	vehicle	9
service	6	warranty	3	design	9
cost	6	brand	3	performance	8
requirements	6			service	8
reliable	6			without	8
high	6			means	7

Table 16: Open Ended Question Word Pair Frequency Details - Quality

Hybrid			Quality			APD		
WORD1	WORD2	FREQUENCY	WORD 1	WORD 2	FREQUENCY	WORD1	WORD2	FREQUENCY
quality	customer	6	product	customer	6	quality	product	15
customer	satisfaction	6	quality	product	5	product	customer	8
product	meets	6	quality	customer	4	quality	means	7
quality	measure	5	product	meets	4	meets	expectations	7
quality	product	5	meets	expectations	4	customers	expectations	7
life	product	5	quality	products	3	life	product	7
meet	customers	5	quality	means	3	product	meets	6
delivering	product	5	product	customers	3	quality	customer	6
quality	means	4	product	service	3	products	meet	5
customer	expectations	4	customers	want	3	meet	customer	5
product	customer	4	products	meet	3	customer	product	5
product	expectations	4				product	exceeds	5
product	service	4				product	performs	5
product	customers	4				product	functions	5
customers	expectations	4				intended	function	5
customers	needs	4				quality	part	5
meets	expectations	4				meets	exceeds	5
quality	design	3				expectations	life	5
quality	ability	3				life	vehicle	5
quality	excellence	3				failure	modes	5
quality	delivering	3				meet	customers	4
quality	part	3				meet	expectations	4
quality	providing	3				customer	life	4
expectations	life	3				customer	satisfaction	4

The OptiComm results for the ADP group responses to the definition of "quality" suggest that the word path for reinforcing the link between the words "quality" and "customer" is: [21] [quality -> product -> customer] because it has the highest average pair frequency of 11.5. (see Figure 15). This would suggest the APD team believes the path from quality to the customer is through products that meet customer expectations.

Figure 15: OptiComm Output ADP Definition of Quality

[Distance] path (Average pair frequency)

All paths
[0.1667] quality -> customer (6.0000)
[0.1917] quality -> product -> customer (11.5000)
[0.4833] quality -> product -> meets -> customer (8.3333)
[0.6012] quality -> means -> product -> customer (6.0000)
[0.7000] quality -> part -> customer (3.5000)
[0.7333] quality -> products -> meet -> customer (4.3333)
[0.7667] quality -> product -> meet -> customer (7.3333)
[0.7667] quality -> product -> exceeds -> customer (7.3333)
[0.7917] quality -> delivering -> product -> customer (4.6667)
[0.8250] quality -> part -> product -> customer (5.0000)
[0.8929] quality -> means -> product -> meets -> customer (5.0000)
[0.9000] quality -> product -> expected -> customer (6.6667)
[0.9333] quality -> product -> meets -> exceeds -> customer (7.0000)
[1.0000] quality -> satisfaction -> customer (2.0000)
[1.0167] quality -> product -> intended -> function -> customer (6.5000)
[1.0667] quality -> product -> function -> customer (6.3333)

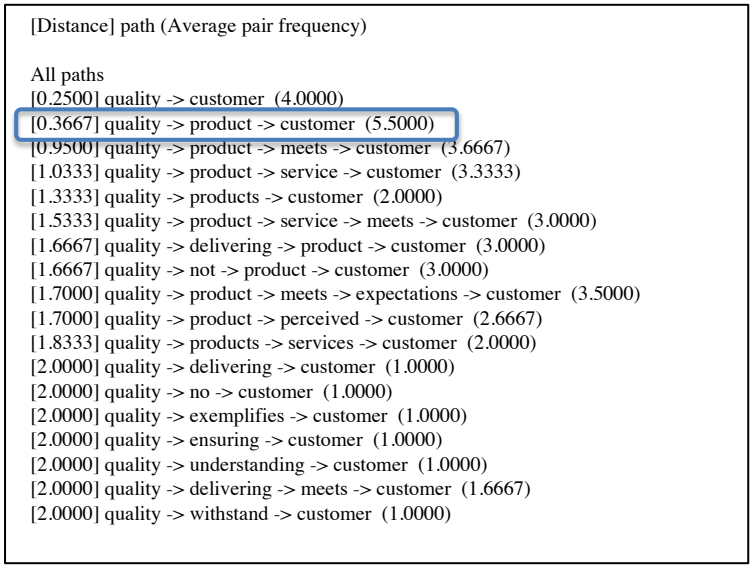
The Atlas.ti details revealed some additional insights into the meaning of the word and word pair frequencies and OptiComm output. ADP team members had this to say, *"Quality means producing a product that meets or exceeds the customers' expectations and does so over time."* (92:3) and *"Delivering your product to the highest standards expected by your customer. The happy harmony of well understood requirements, appropriately selected components and proper assembly"* (92:6).

The Quality group responses to the definition of QUALITY showed the words *quality, customer, and product* were the most mentioned words in the response with a frequency of 24, 20, and 20, respectively (see Table 15). The word pair frequencies for the response to the same

[21] For this analysis the seed word was "quality" and the target word "customer". Innovation did not show up in the responses for the definition of quality for any of the groups.

question were *"product customer", "quality product", and "quality customer"* with frequencies of 6, 5, and 4, respectively (see Table 16). As seen in Figure 16, the OptiComm results for the Qualtiy group responses to the definition of "quality" suggest that the word path for reinforcing the link between the words "quality" and "customer" is [quality -> product -> customer] because it has the highest average pair frequency of 5.5. This word path is identical to the word path for the definition of quality from the APD group and can be interpreted to mean quality to the customer is through quality products meeting customer expectations.

Figure 16: OptiComm Output Quality Group Definition of Quality

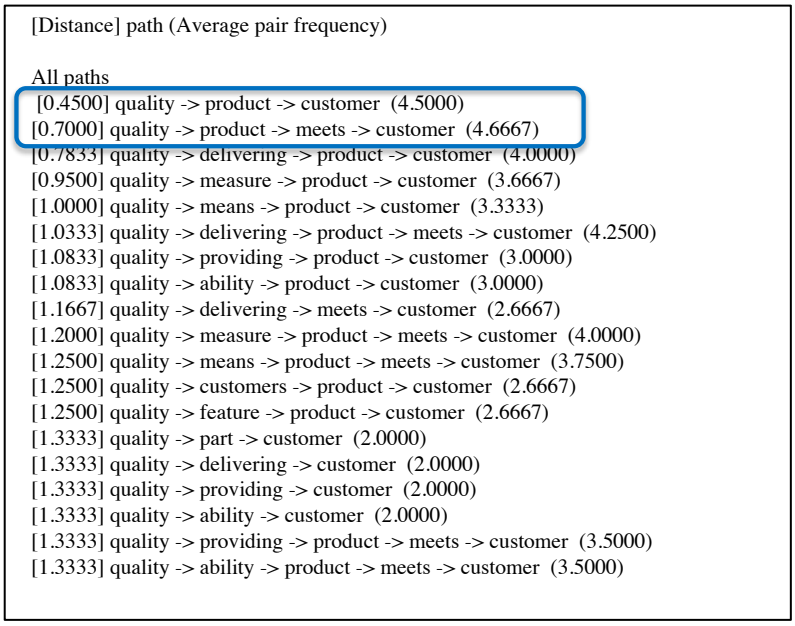


Notable quotes from the quality group relative to the definition of quality include, *"[Quality] provides a product or service that consistently meets the customer's expectations" (88:10), and "Quality is product that surprises and delights customers while delivering basic performance without defects or degraded performance" (88:21).*

The Hybrid group responses to the definition of QUALITY showed the words *quality, product, and customer* were the most mentioned words in their response with frequencies of 54, 47, and 27, respectively (see Table 15). The word pair frequencies for the response to the same question were "quality customer", "customer satisfaction", and "product meets" with frequencies

of 6 for all of the word pair combinations (see Table 16). The OptiComm results for the Hybrid group responses to the definition of "quality" suggest that the word path for reinforcing the link between the words "quality" and "customer" is [quality -> product -> meets -> customer] because it has the highest average pair frequency of 4.67 (see Figure 17). The word path [quality -> product -> customer] is the same word path as that identified with the ADP and quality groups.

Figure 17: OptiComm Output Hybrid Group Definition of Quality


[Distance] path (Average pair frequency)

All paths
[0.4500] quality -> product -> customer (4.5000)
[0.7000] quality -> product -> meets -> customer (4.6667)
[0.7833] quality -> delivering -> product -> customer (4.0000)
[0.9500] quality -> measure -> product -> customer (3.6667)
[1.0000] quality -> means -> product -> customer (3.3333)
[1.0333] quality -> delivering -> product -> meets -> customer (4.2500)
[1.0833] quality -> providing -> product -> customer (3.0000)
[1.0833] quality -> ability -> product -> customer (3.0000)
[1.1667] quality -> delivering -> meets -> customer (2.6667)
[1.2000] quality -> measure -> product -> meets -> customer (4.0000)
[1.2500] quality -> means -> product -> meets -> customer (3.7500)
[1.2500] quality -> customers -> product -> customer (2.6667)
[1.2500] quality -> feature -> product -> customer (2.6667)
[1.3333] quality -> part -> customer (2.0000)
[1.3333] quality -> delivering -> customer (2.0000)
[1.3333] quality -> providing -> customer (2.0000)
[1.3333] quality -> ability -> customer (2.0000)
[1.3333] quality -> providing -> product -> meets -> customer (3.5000)
[1.3333] quality -> ability -> product -> meets -> customer (3.5000)

The similarity of definitions indicates that there is shared meaning across the organization for quality, but there is not complete shared meaning for innovation.

The WORDij function QAPnet was used to measure the overall similarity of the three semantic networks of the three groups (ADP, Quality, and Hybrid) using a correlation coefficient. Correlations can range from -1.00 a perfect negative correlation to +1.00 a perfect positive correlation. For this study the results revealed a negative correlation between the Quality and APD group of -0.316 for the definition of innovation, and -0.272 for the definition of quality. The details for this and all other comparisons can be found in Table 17 and Table 18.

Table 17: QAPnet - Word Pair Correlations Summary - Innovation Definition

	Quality	Advanced Product Design	Hybrid
Quality	+1.00		
Advanced Product Design	-0.316	+1.00	
Hybrid	-0.365	-0.180	+1.00

Table 18: QAPnet - Word Pair Correlations Summary - Quality Definition

	Quality	Advanced Product Design	Hybrid
Quality	+1.00		
Advanced Product Design	-0.272	+1.00	
Hybrid	-0.438	-0.280	+1.00

LIWC Analysis

LIWC was run for all six of the definition scenarios (ADP, Quality, and Hybrid by Innovation and Quality) to calculate the positivity index between the three groups. The results show for the definition of INNOVATION, the quality group had the highest positivity index score of 12.21, which was more than three times the positivity score for the ADP group at 3.69 and 2.82 times the positivity score of the hybrid group; the hybrid group positivity index score was 4.31. For the definition of QUALITY, all of the group's positivity scores were relatively the same at 2.30, 2.23, and 2.82 for the ADP, quality, and hybrid groups, respectively. These results again support the interpretation that the perception of quality is consistent across all three groups, whereas there is more variation around the concept of innovation.

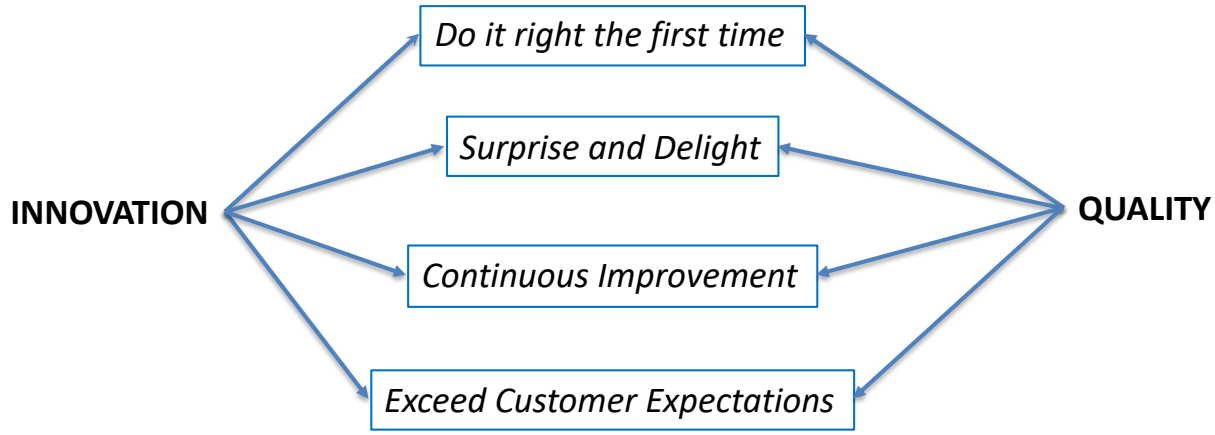
Table 19: LIWC Survey Results - All Groups

	Innovation	Quality
Advanced Product Design	3.69	2.30
Quality	12.21	2.23
Hybrid	4.31	2.82

Atlas.ti Analysis

Once all of the definition text files were loaded into Atlas.ti, they were coded using many of the codes that were established during the interview analysis and also with some new codes that emerged during analysis. There were some interesting discoveries while coding these responses. First, there were codes that were similar for both the definition of innovation and quality. Both innovation and quality were linked to "do it right the first time". There were three quotes associated with these similar definitions. For innovation, one quote was, "Innovation is being the first to show customers new technology and advancements and doing it right the first time"; and for quality, one of the quotes was, "Doing it right the first time and every time". Another similarity between the definition for the two words was the reference to surprise and delight. There were 15 references to surprise and delight for the definition of innovation and 10 references to the same for the definition of quality. One reference to surprise and delight was for the definition of innovation: "Surprise and delight is enabler of innovation". In reference to quality, one of the respondents stated for surprise and delight that, "Quality is meeting customer expectations. Providing new technologies that surprise and delight the customer and that don't have error states that require repairs. Quality has cost added to it. Great quality should not cost a lot." These examples illustrate the similarities in the definitions of quality and innovation. Others include "exceed customer expectations", and "continuous improvement", indicating that achieving or exceeding customer expectations may be a process or a journey of continuous improvement. Figure 18 illustrates the common definitions of innovation and quality.

Figure 18: Common Definitions for Innovation and Quality



Discussion

Results from this study provide insights into the proposed research question; how do engineers working in conceptual design and those working in quality understand each other and the meaning of innovation and quality? First, the interviews with the leaders of the Fortune 50 firm provided insights into the way innovation and quality are perceived at the various leadership levels. It was clear that the managers and chief engineers were more focused on the tactical objectives of the organization and the director and vice president level leaders were mainly focused on the strategic objectives of the organization. Their responses helped to inform the construction of the survey and confirmed the elements of the proposed conceptual model for the quantitative portion of this study, including culture, information flow, and team interactions. Second, it was evident in both the interviews and the survey that the interview and survey participants agree that innovation is about creating new ideas and concepts that help to improve the customer experience. However, the survey participants did not agree on the definition for the word INNOVATION. The OptiComm results obtained showed some differences in the way innovation and quality are connected semantically among the groups, so it cannot be assumed that the various groups are can be targeted with the same message to achieve alignment on the definition. They all agree that an

innovation is something that is perceived as new, which is aligned with the definition established by Everett Rogers (2003, 2011), but the semantic network paths are not quite the same. There is a difference in the way the words are put together in messages that connect innovation with quality. On the other hand, the semantic path for quality was identical among the groups based on the OptiComm results, and aligned with the definition provided by the American Society of Quality that quality is "the characteristics of a product or service that bear on its ability to satisfy stated or implied needs." Because the semantic network path about quality --> innovation is the same for all three groups, the same message resonates with all three groups. Different messaging has to be used in talking about innovation --> quality in the three groups as the message network paths are not the same.

In addition to the output from WordLink and OptiComm, the output from the QAPnet module also provided the finding that the word pair correlations between the quality group and the advanced product design group had a correlation value of -0.316 for the definition of innovation, and -0.272 for the definition of quality, indicating a wider gap in meaning around innovation for the two groups than there is around quality.

For this study, we researched the shared meaning of the words innovation and quality among quality and advanced product design team members. The final survey was designed to solicit the definitions from three groups, those from quality, advanced product design, and those that associated with both groups. This was done to determine if having both experiences would provide more insight into the language among team members. Based on the study, there were differences in language for all three groups when asked about the definition of innovation, but there was not difference in the definition for quality. This would suggest the definition for quality has been well communicated and enforced at the firm, but the definition for innovation has not.

The original proposition only called for the comparison between the quality and advanced product design teams, so to that end, and based on these results, Proposition 2a which states the language of the conceptual design teams will be different than the language of the quality team is supported, and Proposition 2b which states the meaning of innovation and quality as understood by the conceptual design team(s) (ADP) will be different than the meaning as understood by the quality team, is partially supported.

CHAPTER 6: QUANTITATIVE RESEARCH RESULTS

Sample and Data Collection Procedure

In this study the unit of analysis was a single Fortune 50 firm. A survey was issued to 4,936 advanced product design and quality professionals during July 2019. There were 314 professionals that completed the entire survey representing a 6.4 % response rate. These professionals worked for three divisions (quality, product development, and research and advanced engineering) of the firm and were located nationwide. For this study, the product development and research and advanced engineering team members will be combined as one group known as the advanced product design (APD) group. As shown in Table 20 , 62.74% were from advanced product design, 15.61% were from the quality group, and 21.66% classified themselves with a different group known as "other", which includes areas such as research, safety, vehicle programs, software, and manufacturing. For this study, all of the survey participants were asked to identify where they had experience, in either the advanced product design group, quality group, or both; of those that responded 53.82% associated with advanced product design, 12.74% with quality, and 33.44% with both (also known as "hybrid") (see Table 20).

Table 20: Sample Demographics

What is your Current Work Area?				
	Quality	Advanced Product Design	Other	Total
Count	49	197	68	314
Percentage	15.61%	62.74%	21.66%	

What Areas have you had experience in?				
	Quality	Advanced Product Design	Both	Total
Count	40	169	105	314
Percentage	12.74%	53.82%	33.44%	

Data was collected using Qualtrics, a popular online survey research platform. The introduction to the survey explained the objectives of the survey and included the support of senior leadership in its completion. It was explained that the purpose of the survey was to understand the intersection of innovation and quality. To maximize response rates and reduce social desirability bias we guaranteed anonymity, collected no personally identifiable information, offered to provide a copy of the results, and assured that only the researchers would have access to the data. Before the final survey was administered, a pre-test survey was sent to several quality and advanced product design professionals for evaluation. Feedback from the pre-test participants resulted in removal of one question. The survey was revised and tested again in a pilot study conducted with 20 professionals. This study survey sought to ensure that the initial statistical results were in line with construct definitions. The initial survey results were analyzed against the Competing Values Framework construct. The preliminary results show that the NOW to PREFERRED Competing Values Framework shifted from clan-adhocracy-hierarchy-market to clan-adhocracy-market-hierarchy. After the pilot survey was issued, feedback was received from one of the participants that suggests the survey was too long. A deeper look into the data showed that some of the questions could be skipped. This resulted in making a change to the questions for a forced response; one of the question setup selection options. This selection would require all the key questions be answered before the participants could move to the end of the survey, thus ensuring a better completion rate.

Data Screening

The data were cleaned to remove any respondent's data that had more than 5% missing responses. For those occasional questions that had any missing responses, the mean value for the

variable was substituted. It is important to note that the use of a 5-point scale limits the effects of skewness and kurtosis. Additionally, our data set was sufficiently large to reduce the effects of skewness and kurtosis on results and aside from the missing values we did not need to transform the data.

Cultural Assessment

Prior to creating the measurement model, it was important to explore the culture types of the groups, quality, advanced product design (APD), and hybrid using the Organizational Culture Assessment Instrument (OCAI) from the Competing Values Framework by K. S. Q. Cameron, Robert E. (2011). The OCAI was distributed as a part of the complete survey to all members of the research and advanced engineering, product development, and quality organizations. The objective of the OCAI is to assess six key dimensions of organizational culture as described in Chapter 4. The six OCAI consists of four options that are aligned with the Competing Values Framework culture types; clan, adhocracy, market, and hierarchy (See Figure 2). The 5-point Likert scale assessment was completed by the respondents for the NOW and PREFERRED scenarios as described in Chapter 4. The groups were separated into the quality, advanced product design, and hybrid groups. The results of the survey show that all of the three groups associated themselves mainly with the clan culture type in both the NOW and PREFERRED scenarios. All of the culture type scores shifted up in range from the NOW to the PREFERRED scenarios most likely due to the respondents seeing the PREFERRED scenario as an improvement over the NOW scenario in all cases.

Quality Group

The quality group scores in the NOW scenario ranged from 2.78 to 3.24 then shifted in the PREFERRED scenario from 3.95 to 4.27. The culture type order for the quality group went from

clan-adhocracy-market-hierarchy for the NOW scenario to clan-adhocracy-hierarchy-market for the PREFERRED scenario. It was interesting to see the hierarchy culture type move up above the market culture type in the PREFERRED scenario. Based on these findings, Proposition 1a, "the quality organization will have a hierarchy culture type", is not supported.

Conceptual Design Group

The conceptual design group scores in the NOW scenario ranged from 2.77 to 3.13 then shifted in the PREFERRED scenario from 3.55 to 4.23. The culture type order for the conceptual design group remained unchanged between the two scenarios with clan-adhocracy-market-hierarchy. Based on these findings, Proposition 1, "Conceptual Design teams will have an Adhocracy culture type" is not supported. It is interesting to note that for the PREFERRED scenario, the gap between the clan and adhocracy culture types shifted from 0.32 points to 0.05 points, giving more importance to the adhocracy culture type. Figure 19 and 20 illustrate the culture mapping for all groups in the NOW and PREFERRED scenarios, with Table 21showing the culture scores for all groups. More research should be done to understand the phenomenon's that surfaced from the OCAI.

Next, to test this study's conceptual model, a measurement model is built and tested to understand the causal relationships of the conceptual model's constructs.

Measurement Models

Exploratory Factor Analysis: NOW Scenario. For the OCAI scale items for the NOW scenario, a principal axis factoring with Promax rotation with direct oblimin rotation was used to examine the initial factor structure (EFA see Appendix F). Following Hinkin's (1998) recommendation, we used the following criteria to determine the number of factors: eigenvalue greater than 1 and the scree test of the percentage of variance explained (Cattell, 1966).

Figure 19: Culture Map - All Groups NOW Scenario

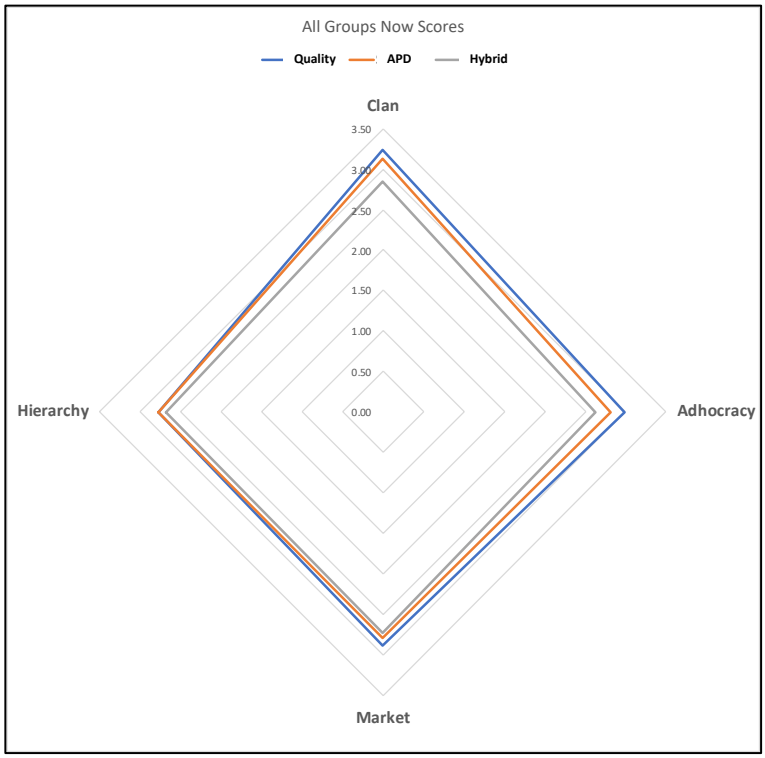


Figure 20: Culture Map - All Groups PREFERRED Scenario

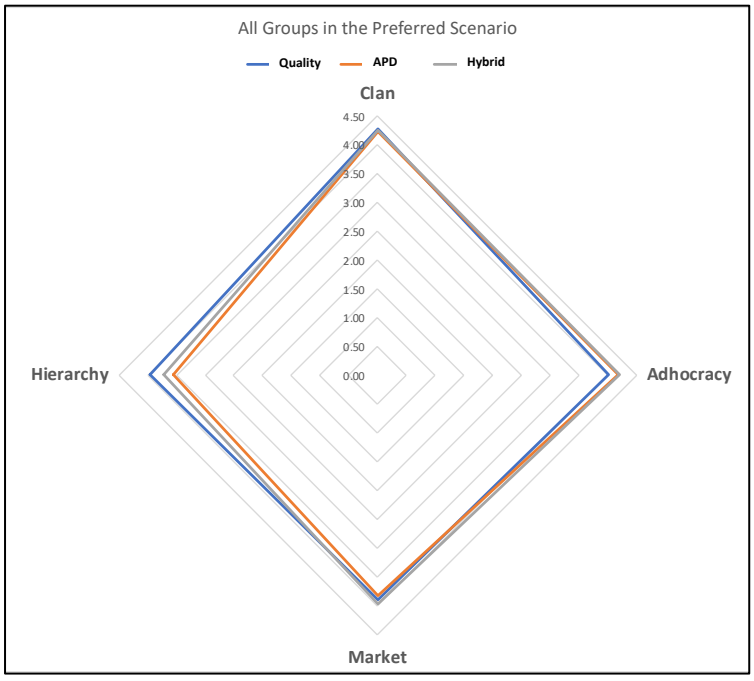


Table 21: Culture Scores

Quality			Conceptual Design			Both		
	Now	Preferred		Now	Preferred		Now	Preferred
Clan	3.24	4.27	Clan	3.13	4.23	Clan	2.84	4.25
Adhocracy	2.98	4.02	Adhocracy	2.81	4.18	Adhocracy	2.62	4.21
Market	2.89	3.89	Market	2.79	3.83	Market	2.73	3.97
Hierarchy	2.78	3.95	Hierarchy	2.77	3.55	Hierarchy	2.68	3.72

Based on these criteria, a nine-factor solution was identified. We then examined the factor loadings and cross-loadings of the items. Items were retained if (a) they had high loadings on their primary factor (i.e., l > .40) and (b) they had low cross-loadings on any other factor (i.e., cross-loadings were less than half of their primary loadings; Hinkin, 1998).

Several statistics indicated the EFA solution was acceptable. First, we observed the Kaiser-Meyer-Olkin (KMO) statistic was 0.912 indicating sampling adequacy. Second, Bartlett's Test of Sphericity was significant (χ^2 = 7855.254, df=1176, p< 0.000) indicating sufficient intercorrelations. Third, the communalities were all above 0.30 further confirming that each item shared some common variance with other items. Fourth, all Measures of Sampling Adequacy (MSA's) across the diagonal of the anti-image matrix were above 0.70, indicating that the data is appropriate for factoring. Fifth, an examination of the inter-item correlation matrix indicated approximately 58% of the correlations were over 0.30. Finally, an additional check for the appropriateness of the respective number of factors that were extracted was confirmed by examining reproduced correlation (and residuals). We found 6% nonredundant residuals with absolute values greater than 0.05.

The eigenvalues showed that the first factor explained 27.59% of the variance, the second factor 7.26% of the variance, and a third factor 6.35% of the variance. Other solutions were examined, however, the nine-factor solution, which explained 61.17% total variance, was

preferred because of its theoretical support, the 'leveling off' of eigenvalues on the scree plot after eight factors, and the number of primary loadings on their hypothesized factors.

Exploratory Factor analysis: PREFERRED Scenario

The factorability of the OCAI items for the preferred scenario was examined. First, several items correlated at least 0.30 or higher with at least one other item, suggesting reasonable factorability. Secondly, the Kaiser-Meyer-Olkin measure of sampling adequacy was 0.882, above the recommended value of 0.60, and Bartlett's test of sphericity was significant (χ^2 (1225) = 7323.745, $p < .001$). The diagonals of the anti-image correlation matrix were all over 0.50, supporting the inclusion of each item in the factor analysis. Finally, the communalities were all above 0.30 further confirming that each item shared some common variance with other items.

An initial analysis was run to obtain eigenvalues for each component of the data. Initial eigenvalues indicated that the first factor explained 20.797% of the variance. The remaining eight factors had eigenvalues over Kaiser's criterion of 1 and in combination explained 59.341% of the variance.

The EFA's outlined above are useful to address the question of whether the four item types are equally-likely to produce separate factors in typical applied management research. However, since they are not theoretically-driven, EFA's tend to capitalize on chance error in a data set; additionally, they do not allow the clear partitioning of variance into separate trait, method, and error components (Fornell & Larcker, 1981; Schmitt & Stults, 1986). Thus, a series of CFA's were conducted employing the maximum likelihood estimation procedures.

Confirmatory Factor Analysis

The measurement model was estimated using AMOS (Analysis of Moment Structures) software v25.0, a covariance-based structural equation modeling technique using the maximum

likelihood estimation approach. In this model, no unidirectional path was specified between any latent. Instead, a covariance model was estimated where each latent variable was correlated with every other latent variable.

The psychometric properties of the latent constructs involving forty-six items were evaluated simultaneously in one confirmatory factor analysis (CFA). The sample size of 314 was deemed sufficient given low communalities (Hair, Black, Rabin, & Anderson, 2010) and acceptable values on the Hoelter's Critical N test. Consequently, the model was expected to converge using maximum likelihood estimation.

The CFA model showed reasonable goodness of fit after the removal of 4 items and the covariance of errors as shown in Table 22

Table 22: CFA Model Fit Statistics

Model Fit Measures	Threshold	CFA Model	References
Chi-Square		1606.987	
p-value	*<0.05*	0.000	
CMIN/DF	*<2*	1.702	Tabachnik & Fidell (2007)
PCFI	*>0.5*	0.825	Hu & Bentler (1999)
CFI	*>0.95*	0.904	Hu & Bentler (1999)
RFI	*>0.95*	0.778	Hu & Bentler (1999)
IFI	*>0.95*	0.905	Hu & Bentler (1999)
TLI	*>0.95*	0.895	Hu & Bentler (1999)
RMR	*<0.08*	0.082	Hu & Bentler (1999)
RMSEA	*<0.06*	0.047	Hu & Bentler (1999)
PCLOSE	*>0.5*	0862	Joreskog & Sorborn (1993)

Confirmatory Factor Analysis: Reliability and Validity

Tests were conducted to evaluate the convergent and discriminant validity and the reliability of reflective measures.

Convergent Validity

Convergent validity used the three standards recommended by Bagozzi and Yi (1988) to assess the measurement model: (1) all indicator CFA factor loadings should exceed 0.5 (Hair et al., 2010); (2) CR should be above 0.7; and (3) the average variance extracted, AVE, of every construct should exceed 0.5 (Fornell & Larcker,1981).

Hair et al. (2010) suggests an item is significant if its factor loading is greater than 0.50. the factor loadings demonstrate convergent validity at the item level. At the construct level, Hair et al. (2010) recommends that the composite reliability should be used in conjunction with SEM to address the tendency of the Cronbach's alpha to understate reliability. For composite reliability to be adequate, a value of .70 and higher was recommended (Nunnally & Bernstein, 1994). As shown in, the composite reliability for all factors is 0.7 or higher, confirming model reliability. The final indicator of convergent validity is the average variance extracted, which measures the amount of variance captured by the construct in relation to the amount of variance attributable to measurement error (Fornell & Larcker, 1981). Convergent validity is judged to be adequate when average variance extracted equals or exceeds 0.50 (i.e. when the variance captured by the construct exceeds the variance due to measurement error). As shown in Table 23, the convergent validity for the proposed constructs of this study is not met for four of the nine constructs. To improve the AVE for these constructs and as recommended by Ping (2009) observed variables were removed from the latent variables one at a time. The AVE values only improved marginally with each removed observed variable. Eventually, the removal of six observed variables caused the measurement model to become unstable and unable to produce a model. Given the unique context of these elaborate measures and having used them for the first time in an automotive setting with advanced product design and quality types, a lower than expected AVE is not unusual. This model

together with the theoretical model-testing studies will be considered largely "exploratory". (Ping, 2009)

Discriminant Validity

In discriminant validity, as Fornell and Larcker (1981) suggested, the AVE of construct should exceed other correlation coefficients of the construct. Table 23 shows the matrix of correlations among the constructs in this research. Diagonal elements are the square roots of the average variance extracted (AVEs) for the constructs. The correlation coefficients between any two constructs are smaller than the square root of the average variance extracted for the constructs. The results suggest more measurement work is necessary on the low validity measures of this first - time study (Ping, 2009). Finally, to examine the discriminate validity of the measurement model, the correlations among latent constructs were examined. High value correlations exceeding 0.9 (Hair, et al. 2010) or correlations exceeding 0.85 (Kline 1998), should be noted as an indication of a problematic level of inter-correlated constructs. There were no high value correlations identified in the model measures.

Table 23: Correlation Among Constructs

				Correlation Among Constructs								
Construct	**CR**	**AVE**	**MSV**	**CVFClan**	**CVFAdhocracy**	**CVFMarket**	**CVFHierarchy**	**InfoExchange**	**Conflict**	**Connected**	**QualityPerf**	**ADPPerf**
CVFClan	0.856	0.504	0.631	**0.71**								
CVFAdhocracy	0.859	0.506	0.631	0.794***	**0.711**							
CVFMarket	0.785	0.38	0.349	0.541***	0.560***	**0.616**						
CVFHierarchy	0.728	0.409	0.502	0.708***	0.497***	0.591***	**0.64**					
InfoExchange	0.859	0.605	0.516	0.669***	0.585***	0.476***	0.597***	**0.778**				
Conflict	0.806	0.411	0.537	-0.585***	-0.566***	-0.370***	-0.394***	-0.660***	**0.641**			
Connected	0.742	0.369	0.537	0.500***	0.447***	0.398***	0.341***	0.718***	0.732***	**0.607**		
QualityPerf	0.818	0.602	0.502	0.347***	0.357***	0.388***	0.403***	0.481***	0.335***	0.397***	**0.776**	
ADPPerf	0.908	0.622	0.502	0.447***	0.462***	0.383***	0.406***	0.568***	0.356***	0.401***	0.708***	**0.789**

Invariance Testing: Multi-group Analysis Measurement

To understand the group effect on the measurement model a multi-group invariance test was completed. Three elements for invariance testing which include configural, metric, and scalar (Schmitt & Kuljanin, 2008). Configural and metric invariance testing are considered the two main invariance tests (Gaskins, 2019), so scalar was not completed for this study. The groups used for this test were the quality and advanced product design groups. To ensure ample sample size for this test, the hybrid group was regrouped into one of the two mentioned groups based on their years of service. According to Gaskins (2019) the sample size should be about the same; unevenness of the sample size may be of concern. The final count for the quality group was 87 and the final count for the advanced product design group was 227. It is expected that the underlying measurement for both groups would be roughly the same (Gaskins, 2016).

Configural

Configural invariance test is performed to see if there is good model fit when modeling multiple groups that have model regression weights that are constrained to be equal. (Gaskins, 2019) The model fit statistics were partially met. This would suggest that the quality and advanced produce design groups answered the questions very differently, which based on the qualitative assessment of the two groups languages completed in Chapter 5 there are differences, so this may not be an issue for this model.

Metric

Metric invariance test does a chi-square difference test to determine measurement equivalence between the two groups. For this study, the p value must be greater than 0.05. The initial run output showed the p-value below the 0.05 threshold. This required the removal of measurement weights until the p-value improved, without removing a majority of the measurement weights for any single factor. Without removing all of the measurement weights for any single

factor, the p-value improved to be 0.063, which met the threshold described above. Items are similar for the quality; there was invariance.

Common Method Bias

Common method bias (CMB) is a frequent concern when conducting cross-sectional, self-reported research; it refers to the variance that is attributable to the measurement method rather than to the constructs. Method biases can be one of the main sources of measurement error and researchers agree that common method variance is a potential problem in behavioral research (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003).

Podsakoff et al. (2003) provide recommendations to the survey design to reduce the sources of common method bias. First, the respondent's anonymity was ensured (see Participation Letter in Appendix D) to reduce the likelihood of socially desirable answers. Next, the survey provided unambiguous answer scales with different formats, and was constructed and pretested in cooperation with an advisor with expertise in survey design. Survey items were randomly ordered so that comfortable answering was possible without disclosing the underlying model structure and to reduce any order bias.

If the dependent and independent variables are collected using the same instrument, then we just check for Common Method Bias. There are many ways to do this, but the simplest way is to use a common latent factor, or CLF. A common method factor analysis was run using AMOS. To accomplish this a common latent factor was added to the CFA model, and then connected to all observed items in the model. The standard regression weights from the CFA model were then compared to the standardized regression weights of the zero constrained model. The chi-squared came out to be significant with a p-value < 0.05. We had significant shared variance which would

lead us to retain the CLF for development of the structural model. The model fit statistics for this model are shown in Table 24.

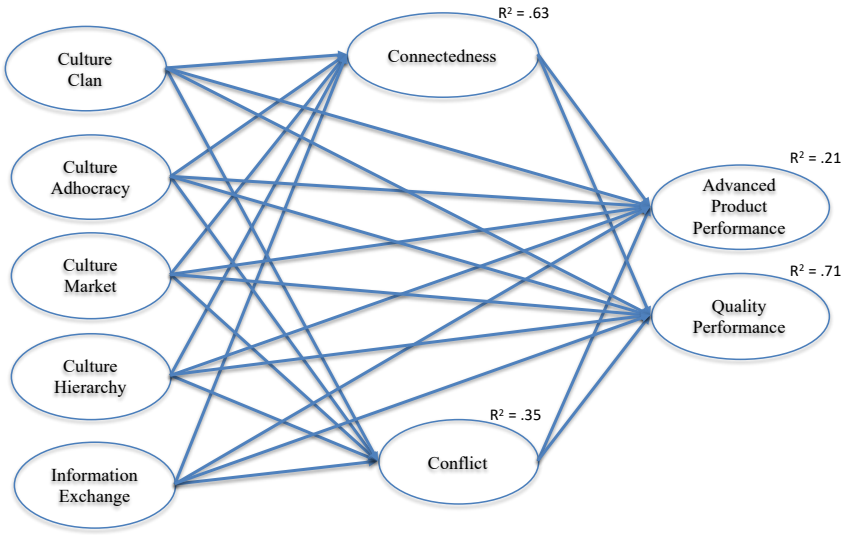
Table 24: Common Method Bias Test Model Fit Statistics

Model Fit Measures	Threshold	CFA Model	References
Chi-Square		1555.867	
p-value	*<0.05*	0.000	
CMIN/DF	*<2*	1.684	Tabachnik & Fidell (2007)
PCFI	*>0.5*	0.811	Hu & Bentler (1999)
CFI	*>0.95*	0.909	Hu & Bentler (1999)
RFI	*>0.95*	0.781	Hu & Bentler (1999)
IFI	*>0.95*	0.910	Hu & Bentler (1999)
TLI	*>0.95*	0.898	Hu & Bentler (1999)
RMR	*<0.08*	0.088	Hu & Bentler (1999)
RMSEA	*<0.06*	0.047	Hu & Bentler (1999)
PCLOSE	*>0.5*	0.909	Joreskog & Sorborn (1993)

Structural Equation Model (SEM)

The structural model defines relations among the unobserved variables and specifies the manner by which latent variables directly or indirectly influence changes to the values of other latent variables in the model as seen in Figure 21 (Byrne, 2013).

Figure 21: Structural Equation Model



The variables were loaded into AMOS. All variables that are not predicted were covaried. All of the prediction paths were created the path model. The path model does not account for error, so error terms were added to anything that was predicted. The original model was run for model fit, but the model fit statistics suggested the model was inadequate. To resolve the model fit concerns, the variables for culture and information exchanged were connected to the performance variables. Connecting the conflict predictor variable to the quality performance variable and the connectedness variable to the conflict variable also helped to improve model fit. The final structural model fit statistics are represented in Table 25.

Table 25: Structural Equation Model Fit Statistics

Model Fit Measures	Threshold	Structural Model	References
Chi-Square		3.616	
p-value	*<0.05*	0.057	*Non Significant*
CMIN/DF	*<2*	3.616	Tabachnik & Fidell (2007)
PCFI	*>0.5*	0.028	Hu & Bentler (1999)
CFI	*>0.95*	0.998	Hu & Bentler (1999)
RFI	*>0.95*	0.907	Hu & Bentler (1999)
IFI	*>0.95*	0.998	Hu & Bentler (1999)
TLI	*>0.95*	0.931	Hu & Bentler (1999)
RMR	*<0.08*	0.007	Hu & Bentler (1999)
RMSEA	*<0.06*	0.091	Hu & Bentler (1999)
PCLOSE	*>0.05*	0.157	Joreskog & Sorborn (1993)

Based on the model fit statistics the model was considered good. These statistics give confidence that the model is good.

Given the model fit, we can use the regression weight output to conclude that Proposition 1b is not supported and proposition 1c is partially supported. Proposition 1b states that an organizational culture of adhocracy will be positively related to Interdepartmental Interactions.

The regression weight estimates for the correlation of adhocracy on connectedness was significant at -0.508, while the correlation of adhocracy to conflict was not significant. Proposition 1c states an organizational culture of hierarchy will be negatively related to Interdepartmental Interactions. The regression weight estimates for the correlation of hierarchy on connectedness was significant at -0.155, while the correlation of hierarchy on conflict was not significant.

Multigroup Moderation

Multi-group comparisons are a special form of moderation in which a dataset is split along values of a grouping variable (such as gender), and then a given model is tested with each set of data.

A multigroup moderation analysis was run on the original model, with the moderating effect of groups, which for this study are quality and advanced product design groups. The goal of the moderation exercise is to understand the interaction of the variable group on the path between connectedness, conflict and advanced product performance and quality performance. Interaction plots were created, and what we found was that none of the interactions were significant. The interaction plots are described below.

The interaction plot (Figure 22) for conflict and advanced product design performance shows that the relationship between conflict and advanced product design is stronger for the advanced product design team over the quality team. Additionally, the interaction plot (Figure 22) for conflict and quality performance shows that relationship between conflict and quality performance is stronger for the quality group over the advanced product design group.

Based on these results, **Hypothesis 4a, "**The relationship between conflict and advanced product design performance is stronger for the advanced product design group." is not supported because the relationship is not significant. Additionally, **Hypothesis 4b, "**The relationship between

conflict and quality performance is stronger for the quality group" is not supported because the relationship is not significant.

The interaction plot (Figure 23) for connectedness and quality performance shows that the relationship between connectedness and quality performance is stronger for the quality group over the advanced product Based on these results **Hypothesis 4c:** "The relationship between connectedness and advanced product design performance is stronger for the advanced product design team" is not supported because the relationship is not significant. Additionally, **Hypothesis 4d:** "The relationship between connectedness and quality performance is stronger for the quality group" is not supported because the relationship is not significant.

Figure 22: Interaction Plots for Conflict Impact on ADP and Quality Performance

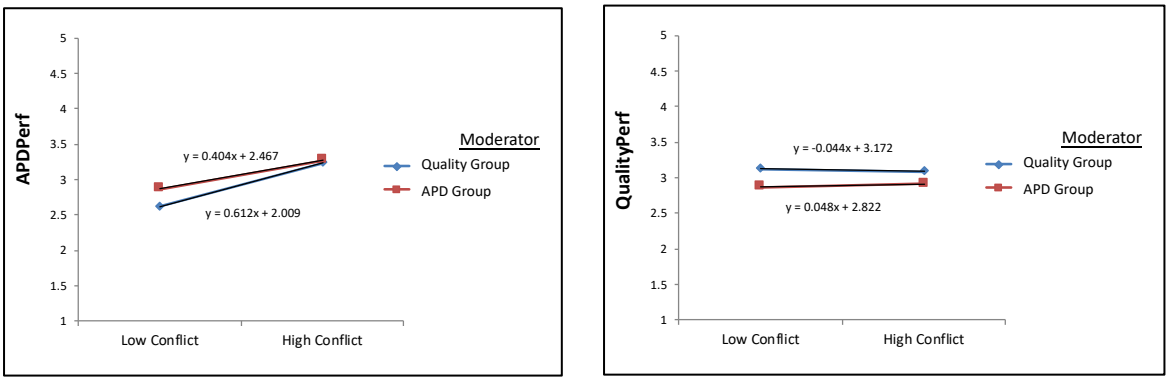


Figure 23: Interaction Plots for Connectedness Impact on ADP and Quality Performance

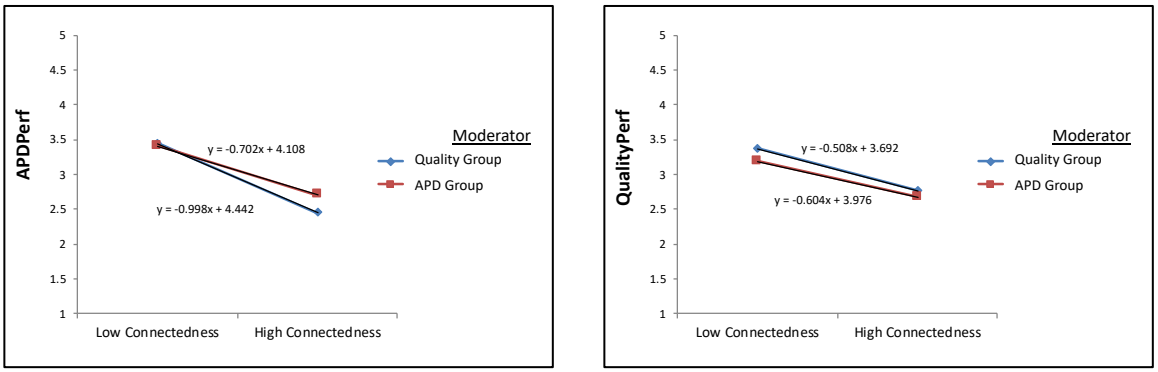


Table 26 provides a summary of the proposition and hypothesis tests for this study. Conclusions, implications of research and recommendations for future research are provided in Chapter 7.

Table 26: Proposition and Hypotheses Summary Table

Test Type and Number	Supported
Proposition 1: Conceptual Design teams will have an Adhocracy culture type.	No
Proposition 1a: The Quality organization will have a Hierarchy culture type.	No
Proposition 1b: An organizational culture of adhocracy will be positively related to Interdepartmental Interactions.	No
Proposition 1c: An organizational culture of hierarchy will be negatively related to Interdepartmental Interactions.	Partial
Proposition 2a: The language of the conceptual design team(s) will be different than the language of the quality team.	Yes
Proposition 2b: The meaning of innovation and quality as understood by the conceptual design team(s) will be different than the meaning as understood by the quality team.	Partial
Propositions 3a – 3e: All network structure propositions were withdrawn from this study.	N/A
Hypothesis 4a: The relationship between conflict and advanced product design performance is stronger for the advanced product design group.	No
Hypothesis 4b: The relationship between conflict and quality performance is stronger for the quality group.	No
Hypothesis 4c: The relationship between connectedness and advanced product design performance is stronger for the advanced product design group.	No
Hypothesis 4d: The relationship between connectedness and quality performance is stronger for the quality group	No

Discussion

Similar to the qualitative portion of this study, the quantitative analysis used different tools to assess various elements of the research questions including understanding the culture of the various teams being evaluated, and the impact interdepartmental interactions has on quality and advanced product design performance in a Fortune 50 automotive firm. First, the culture was assessed using the results of a survey that was administered to three organizations; product

development, research and advanced engineering, and quality. For this study, the survey respondents were asked to answer the survey questions based on experiences they had with fast to market innovation. The survey required the respondents to choose which area they had experience in; either advanced product design, quality, or both. The culture portion of this study used the results from each of the three groups being evaluated to find that all of the groups identified with the Clan culture type. Which means that they all identify with a collaborative type culture that has a leader as mentor and team builder. This difference in the culture proposed and the culture assessed by the survey participants was unexpected but could be explained by the recent organizational changes at the firm. The recent leadership of the firm is focused on transforming the culture to one this is more collaborative and creative.

The structural equation model was used to understand the effect that the group type had on the relationship between interdepartmental interactions and quality performance and advanced product design performance. For the SEM analysis, two groups, advanced product design and quality, were used to understand the moderating effect of group type on advanced product design performance and quality performance. The analysis shows that the group responsible for the performance of the respective corporate strategies (i.e. quality group for quality performance and advanced product design for advanced product design performance) had a stronger effect on the relationship between the elements of interdepartmental interactions and the respective performance output. Additionally, the analysis showed interdepartmental connectedness has a negative relationship to both quality and advanced product design performance, and interdepartmental conflict had a positive relationship to quality and advanced product design performance. However, there were no relationships from the study that were significant, so the hypotheses associated with interactions is not supported. There is some chance that the effects of

dividing up the *both* group into the advanced product design and quality groups for the multi-group analysis causes some issues with the data. This investigation could be included as work for future research.

CHAPTER 7: CONCLUSIONS

In order for traditional automotive OEMs to compete with the new, more nimble automotive entrants of today, they must find ways to deliver products, including new technologies, to the market faster and with a high level of quality (Gundling, 2016). Scholars have mixed results on whether innovations, including conceptual designs, can be delivered with a high level of quality (Prajogo & Sohal, 2001). This study was performed to better understand whether these two corporate strategies, innovation as it relates to conceptual design and quality, could be delivered at the same time in a traditional automotive environment. The combination of culture, information exchange, and interdepartmental interactions and their impact on advanced product design and quality performance were assessed with a Convergent Mixed Methods approach. An expected major contribution from this study is to understand how engineers working in conceptual design teams and those working in the realm of quality management understand each other, how they define the meaning of innovation and quality, the perceived culture type of the quality and advanced product design teams by executives of the firm, and the impact that the interdepartmental interactions, connectedness and conflict, of these teams have on the a firms advanced product design and quality performance. The remainder of this chapter presents the study implications for theory and practice while acknowledging the study's limitations and setting the stage for future research on this very important topic.

Limitations

There are several limitations of this research study that should be considered. First, the participants for the interviews and survey were all employed by the same Fortune 50 automotive firm, and 92.4% of the respondents were from the Southeast Michigan area. There is some chance

that regional and industry biases exist in the responses. Future research should expand the demographics to other industries and regions.

Secondly, there were discriminate issues with the culture factors in the measurement model. While some scholars have shown positive results applying the Competing Values Framework (CVF) framework to their research of executives in the public utility industry (Kalliath, Bluedorn, & Gillespie, 1999), problems applying the subscales to an audience of non-managerial level employees in the Veteran's Health Administration (VHA) were encountered and discriminate validity issues were of concern in the research study by Helfrich, et al. (2007). Further research for this study should investigate the underlying issue of discriminate validity for CVF factors in the case where there was a mix of survey respondents. For this study, it is also possible that a different structural equation modeling tool would have provided different, and favorable results.

Lastly, issues related to memory recall may have affected response patterns. In the qualitative investigation, the tendency to recall positive events with more detail (D'Argembeau & Van der Linden, 2004) may have influenced the details provided in the participant's stories. The scholars found that for both past and present experiences, positive events were recalled with more clarity than negative events. This would give some cause to believe that as respondents answered the survey questions related to their experiences of delivering fast-to-market innovations, depending on whether the experience was positive or negative, recall of events may have been affected and reflected in the survey responses.

Theoretical Implications and Future Research

Scholarly research on the intersection of innovation and quality is conflicting (Prajogo & Sohal, 2001). There is literature that suggests there is a positive relationship between innovation

and quality (Prajogo and Sohal, 2011), while other literature suggests these corporate strategies cannot co-exist (J. Zeng et al., 2015). This study researched the intersection of innovation and quality in the automotive industry using various research methods. This research is considered exploratory and provides more suggestive direction rather than definitive direction.

Theoretical Implications

Relative to theory this research contributes to the literature in the area of innovation and quality with reference to the behaviors and practices that facilitate or obstruct the development of fast-to-market innovations that will simultaneously improve quality performance in an automotive setting. Specifically, this research provides insights into the languages that exist among the conceptual design and quality teams of an automotive firm that either support or hinder improved quality and advanced product design performance. We found that there are differences in the language of the teams specifically responsible for improving the quality and innovation performance in an automotive environment. The output from the WORDi, LIWC, and Atlas.ti analyses revealed differences in word linkages, positivity indexes, and definitions. We found that there are similarities and differences in how engineers talk about the two corporate strategies. Relative to quality, all the teams in the firm are aligned on the definition of the word “quality”. The firm has done a great deal of work in communicating and enforcing what quality means relative to the success of the company. On the other hand, the teams are not aligned on the definition of “innovation”. To support closing the gap, it will be important to ensure the definition of innovation is well defined and communicated to all employees of the firm, and how it impacts corporate performance.

This research also contributes to the body of work that understands how culture is perceived by members of an organization or team. We found that the quality and innovation teams

of this automotive firm perceived their current culture to be aligned with the competing values framework or CVF Clan culture type, which is contrary to what has been proposed in the literature. The literature in this space suggests that an innovative culture, that same culture that we expected to be aligned with the advanced product design group, would be one of adhocracy (Cameron and Quinn, 2011) and that a process driving culture, one that aligns with the quality group, would be aligned with a hierarchy culture (Morgan 1993, Glynn 1996, Zeng, Phan et al 2015). Future research could be done to further understand this phenomenon.

Future Research

In addition to shortcomings mentioned in the limitations section, there are other areas that can be explored further to add to this body of research. As the automotive industry goes through the transformation of becoming a mobility industry as outlined in the recent annual reports of both General Motors and Ford Motor Company, further research could help us understand these transformational changes and the impact these changes have on the company and industry. A look into organizational theory could be the start needed to understand what tools and methods are required to handling change in a fast-changing market. Garreth Jones (2013) provides details on the impact of organizational design and how managers can work smarter to ensure increased performance.

Organizational ambidexterity is explained by Duncan (1976) as the characteristic given to an organization that is aligned and efficient in the management of business demands, while also adapting to the changes in the business environment. Recent literature has emerged on the importance of contextual ambidexterity and its impact on overall firm performance (Gibson & Birkinshaw, 2004). The scholars suggest that contextual ambidexterity is focused on building a business unit context that empowers employees to make their own judgement as to when and how

they work on what are considered competing or conflicting demands for alignment and adaptability, as opposed to having two separate organizations that are working toward the successful delivery of competing objectives. In other words, if an employee is given the responsibility and empowered to deliver innovation with high quality and rewarded for achieving both, then organizational performance will improve as a result. Future research aimed at introducing and encouraging contextual organizational ambidexterity in an environment where fast-to-market advanced product design and quality performance must be achieved simultaneously will prove beneficial in a business environment that is changing rapidly.

Additional research into the similarities that exists in the definitions of innovation and quality should be investigated. More research in understanding the underlying connection to the common definitions of innovation and quality; “do it right the first time”, “surprise and delight”, “continuous improvement”, and “exceed customer expectation” could add to this body of work and to theory associated with the intersection of innovation and quality.

In Chapter 5 and considering the message relative to the intersection of innovation and quality, the LIWC positivity index comparison among all interview participants showed that the message and language from the executives that support the vice presidents is more positive than that of the vice presidents themselves. This is contrary to what scholars have found in prior research on transformational leadership. According to the research of Gumusluoglu, Karakitapoğlu-Aygün, and Hirst (2013) on transformational leadership, transformational leaders set the tone of an organization by influencing the worker’s organizational commitment. The study references prior research that illustrates the strong and direct link between transformational leadership and organizational commitment. The research explains that employees that work with transformational leaders show a stronger sense of commitment when there is a collective sense of

mission. One of the characteristics of a transformational leader is inspirational motivation. A leader with inspirational motivation articulates an exciting vision of the future and shows their employees how to achieve goals by expressing their belief that they can achieve them (Gumusluoglu et al., 2013). For this current study, there is some chance that the recent organizational changes at the firm impacted the messaging at the most senior leadership levels. Future research could be designed to understand why this might be the case.

During the time of this study, the firm being researched was going through a major organizational redesign, which meant many of the employees were preoccupied with what was changing and where they were going to be positioned in the company. This also caused some of the employees to withdraw from the research due to the uncertainty that came with changes in the organization. The dynamics associated with these changes prevented the study of network structures in the organization. More research on network structures in an automotive setting could be completed to see how the quality and advanced product design teams align with the definitions provided by scholars relative to network theory (Borgatti & Halgin, 2011; Burt, 2009)

This mixed methods research study focused on the impact that team culture, shared meaning, information exchange, and interdepartmental interactions had on firm quality and advanced product design performance from an employee perspective. The study survey was focused on understanding the perceived quality and innovation performance from the employee point of view. Quality and innovation performance, in the end, is mainly measured by the customer. For quality, the automotive industry has relied on the customer feedback from the JD Power issued Initial Quality Study (IQS) and U.S. Automotive Performance Execution and Layout (APEAL) Study. According to JD Power[22], IQS "serves as the industry benchmark for new-

[22] Jdpower.com

vehicle quality measured at 90 days of ownership and has proven to be an excellent predictor of long-term reliability, which may significantly impact new-vehicle purchase decisions. The focus of the study is model-level performance and comparison of individual models to similar models in respective segments, which helps manufacturers worldwide to design and produce higher-quality vehicles that exceed owners' expectations". And the APEAL study "examines new vehicle owners' assessments of the design, content, layout, and performance of their new vehicle after 90 days of ownership. The study data provides manufacturers and suppliers with insight on quality and design satisfaction". Future research should examine the impact that team factors have on firm performance from a customer point of view.

Practical implications

Based on this researcher's experience, managers in a mature firm must find ways to deliver to the objectives of the company all the while navigating the complexities of organizational culture, and sub-cultures, understanding and potentially adjusting the differences in the way teams communicate what must be delivered, gaining alignment between teams and organizations of the deliverables, and ensuring a steady flow of information to both their teams and to firm executives. This study was designed to understand the underlying dynamics that produce these challenges for managers and to provide some guidance on orchestration.

Interdepartmental Interactions

Research in the marketing and managements fields provide insights into cross-functional demands of product development processes (Gupta, Raj, & Wilemon, 1986; McCann & Galbraith, 1981; Menon et al., 1997). Within this context, achieving product quality goals requires skilled management of interdepartmental interactions within an organization (Menon et al., 1997). Interdepartmental interactions consist of two main aspects, connectedness and conflict. While

interdepartmental connectedness is the degree of informal and formal direct contact among members across departments (Jaworski & Kohli, 1993), interdepartmental conflict is concerned with the tension among departments that is a result of incompatible objectives and goals (c.f. Raven and Kruglanski 1970, p. 70). Menon et al. (1997) research the impact that interdepartmental interactions have on a firm's quality performance given the effect of environmental elements, market turbulence and technological turbulence. This study adds to prior research of understanding the implications to firm quality performance by investigating interdepartmental interaction and the impact it has on the element of firm performance relative to advanced product design for two different groups; advanced product design and quality.

A notable outcome from this research was the relationship between firm performance and interdepartmental interactions. The results show that firm performance, both quality and advanced product design, have a negative relationship to interdepartmental connectedness. This suggests teams perform better when there is a lower level of connectedness between departments. In addition, the converse was true for advanced product design performance; the results show that there is a positive relationship between interdepartmental conflict and the firm's advanced product design performance, suggesting that better advanced product design performance is attributed to a higher level of interdepartmental conflict. On the other hand, interdepartmental conflict had a very slight relationship to quality performance for both the quality and advanced product design teams.

These results are mostly consistent with the literature on network theory (Borgatti & Halgin, 2011) and specifically structural hole theory (Burt, 2009). Given the strong relationship between interdepartmental interactions and firm performance, managers should implement programs that balance interactions based on the impact they have on both advanced product design and quality performance. Menon et al (1997) suggests managers implement interventions that

carefully increase interdepartmental interactions to help improve performance even when connectedness is high. The scholars offer ways to do this, which include providing greater decision-making responsibility to the front-line teams, increasing communications between departments and their respective key constituents, and breaking down functional silos to help build a more cooperative environment for cross-functional teams. Based on the qualitative results of this research, it will be important to clearly communicate the goals of the firm ensuring that all teams understand and are aligned with the meaning of the corporate objectives. Relative to conflict, the scholars suggest reducing the amount of conflict among teams early on in the implementation phase to enhance product performance.

Culture

This study used the work of Cameron and Quinn (2011) and the Competing Values Framework (CVF) to understand the culture, and specifically the sub-cultures, of two groups within a traditional automotive firm. Their book *Diagnosing and Changing Organizational Culture* was written in an effort to educate managers, teachers, and change agents how to diagnose and initiate change in an organization. The CVF theoretical model can be used to help understand an organization's culture makeup and where it should be to achieve its performance goals. The core components or culture types, which are shown in Figure 2, of the CVF are clan (collaborative), adhocracy (creative), market (competing), and hierarchy (controlling). These four clusters of criteria define the core values that are used to make judgements about an organizations culture.

The propositions established for this body of research were defined based on prior literature. According to scholars a hierarchical culture would be rigid and would inhibit innovation by require people to focus on the quality processes rather than on the introduction of new ideas and processes (Glynn, 1996; Morgan, 1993; J. Zeng et al., 2015). Based on this researcher's

experiences, this would be in line with the culture type of a quality organization. Relative to innovation, an innovative organization from a cultural standpoint is directly linked to a culture of adhocracy (Cameron and Quinn, 2011). This theory supported the proposition for the culture type of the advanced product design team of the firm.

To measure team culture the Organizational Culture Assessment Instrument (OCAI) from the Competing Values Framework (Cameron and Quinn, 2011) was distributed as a part of a survey administered to advanced product design and quality engineers. A 5-point Likert scale was used to assess the key characteristics of dominate characteristics, organizational leadership, management of employees, organizational glue, strategic emphasis, and criteria of success for each of the cultural core components. The respondents were asked to recall an experience where they were required to deliver a fast-to-market innovation, and assess the characteristics based on that experience, which was explained in the survey as the NOW scenario, and then to assess the characteristics again based on how they believed the organization characteristics should be, which was explained in the survey as PREFERRED. The results of this survey show that both of the teams, quality and advanced product design, relate more closely with a clan culture type in both the NOW and PREFERRED scenarios. To ensure organizations can deliver both quality and advanced product design performance, it is important for the leadership of the organization to create an environment that balances the attributes associated with each of the culture types at the right time in the product development process. This includes, continuing to nurture an adhocracy culture for improved creativity while maintaining a balanced level of market culture for a strong customer focus (Cameron and Quinn, 2011). The scholars also recommend creating an environment that encourages and supports strategic risk taking for improved advanced product design performance, while balancing the need to ensure strong customer satisfaction. As was

identified in the qualitative portion of this research customer satisfaction is a component of both advanced product design as it relates to innovation, and quality and could be used to bring the two corporate strategies closer together.

Shared Meaning and Information Exchange

To understand the communication and information exchange of the conceptual design or advanced product design team and the quality team, it was important to study the language of these teams relative to the definition of innovation and quality. Based on this researcher's experience, it was proposed that the languages of the advanced product design team and the quality team would be different, and that the meaning of innovation and quality as understood by these teams would be different; the results were mixed. The extensive analysis in this study focused on the semantic and linguistic attributes of interviews with firm executives and responses to the survey open-ended questions for the definition of quality and innovation using three tools; WORDij, LIWC, and Atlas.ti. The analysis revealed some notable findings. First, the positivity index as calculated from the LIWC output, showed that managers and chief engineers had a more positive message than that of the directors and vice presidents. There is no clear explanation for this difference, so a deep dive into this phenomenon could be the basis for further research. On the other hand, the executives were aligned on the fact that delivering both improved quality and advanced product design performance requires obsessive focus on the customer and a culture that embraces risk taking.

Next, it was evident that the interview and survey participants agree that innovation is about creating new ideas and concepts that help to improve the customer experience, which is aligned with the definition established by Everett Rogers (2003, 2011). However, the survey participants were not aligned on the definition for the word *innovation*. The results obtained showed

differences in the way innovation and quality are connected semantically. There is a difference in the way the words are put together in messages that connect innovation with quality between the groups. This is an opportunity for the executives of the firm to establish and communicate the definition of innovation and how it can be achieved, in addition to creating an environment that supports risk taking, collaboration, and information sharing (Subramaniam & Youndt, 2005). Lastly, the managers interviewed agree that the intersection of innovation and quality is possible with a few changes, including listening more and being open to new ideas and new ways of working.

In Closing…

The design and results of this research provide rich insights into the intersection of innovation as it pertains to conceptual design and quality. It provides insights that executives can use toward improving both quality and advanced product design performance. Gaining alignment on the definition of key corporate strategies is a must, ensuring a good communication strategy that all teams can embrace. One example where a good communication strategy can make a significant impact on the language of employees and customers is with Ford Motor Company's marketing slogan "Quality is Job 1"[23]. In the early 1980's, Ford's main quality marketing campaign was created to challenge the rise of the Japanese imports. The slogan would be repeated by both employees and consumers as the staple for Ford products. This successful advertisement has remained in the hearts and minds of those that were around to see it unfold through the 1980's. This could be one of the reasons why those that participated in the survey are so well aligned to the meaning of the word *quality.* Another impactful communication strategy around innovation and quality may be a way for the firm to address the difference in meaning of the word *innovation*.

[23] Autonews.com

It is also important to provide a creative environment that supports innovation, and that delivers fast-to-market advanced product designs with unprecedented quality to the customers in which the firm serves. With a few key organizational and communication changes in the product development process, the intersection of innovation and quality can be achieved.

APPENDIX A: INTERVIEW PARTICIPATION LETTER

Purpose

You are being asked to be in a research study of the intersection of innovation and quality because you a leader in the company. This study is being conducted through Wayne State University. The estimated number of study participants to be interviewed is about 20 throughout the US. **Please read this form and ask any questions you may have before agreeing to be in the study.**

In this research study, the intersection of innovation and quality in the automotive industry will be studied to understand if the two corporate strategies can coexist.

Study Procedures

If you agree to take part in this research survey, you will be asked a series of questions. The survey contains questions about innovation, quality, and their intersection, organizational culture, organizational structure and networks, information exchange, and interdepartmental interactions. Data from this research are intended to inform management about the ways to deal with the challenges of introducing fast-to-market technologies and innovations during the advanced product design process, while ensuring a positive impact on product quality. All completed surveys are strictly confidential. Only aggregated data will be analyzed to understand the general themes perceived by technical professionals. It should take about 15 minutes to complete and is easier to take on a computer.

Benefits

The possible benefits to you for taking part in this research study include understanding how the advanced design teams and quality teams work together. The results of this research will contribute to both practice and theory. Specific to practice, the research will raise awareness by educating management about ways to deal with the challenges of introducing fast-to-market technologies and innovations while ensuring a positive impact on product quality. For theory, the research is expected to contribute to the literature in the area of innovation and quality with reference to the behaviors and practices that facilitate or obstruct the development and implementation of fast-to-market innovations that will simultaneously improve quality performance.

Risks

There are no known risks at this time to participation in this study.

Study Costs

Participation in this study will be of no cost to you.

Compensation

You will not be paid for taking part in this study.

Confidentiality

All information collected about you during the course of this study will be kept confidential to the extent permitted by law. You will be identified in the research records by a code name or number. Information that identifies you personally will not be released without your written permission. However, the study sponsor, the Institutional Review Board (IRB) at Wayne State University, or federal agencies with appropriate regulatory oversight [e.g., Food and Drug Administration (FDA), Office for Human Research Protections (OHRP), Office of Civil Rights (OCR), etc.) may review your records.

When the results of this research are published or discussed in conferences, no information will be included that would reveal your identity.

If photographs, videos, or audiotape recordings of you will be used for research or educational purposes, your identity will be protected or disguised. Any audiotapes will be destroyed after this research is complete. You have the right to review and/or edit the audiotapes. Only the principal investigator will have access to the recordings and they will be erased upon completion of the research study.

Voluntary Participation/Withdrawal
Taking part in this study is voluntary. You have the right to choose not to take part in this study. If you decide to take part in the study you can later change your mind and withdraw from the study. You are free to only answer questions that you want to answer. You are free to withdraw from participation in this study at any time. Your decisions will not change any present or future relationship with Wayne State University or its affiliates, or other services you are entitled to receive.

The PI may stop your participation in this study without your consent. The PI will make the decision and let you know if it is not possible for you to continue.

Questions
If you have any questions about this study now or in the future, you may contact Donna or one of her research team members at the following phone number (248) 687-0722. If you have questions or concerns about your rights as a research participant, the Chair of the Institutional Review Board can be contacted at (313) 577-1628. If you are unable to contact the research staff, or if you want to talk to someone other than the research staff, you may also call the Wayne State Research Subject Advocate at (313) 577-1628 to discuss problems, obtain information, or offer input.

Consent to Participate in a Research Study
To voluntarily agree to take part in this study, you must sign on the line below. If you choose to take part in this study you may withdraw at any time. You are not giving up any of your legal rights by signing this form. Your signature below indicates that you have read, or had read to you, this entire consent form, including the risks and benefits, and have had all of your questions answered. You will be given a copy of this consent form.

_____ _____
Signature of participant / Legally authorized representative * Date

_____ _____
Printed name of participant / Legally authorized representative Time

_____ _____
Signature of witness** Date

_____ _____
Printed of witness** Time

APPENDIX B: IRB APPROVAL DOCUMENT

WAYNE STATE UNIVERSITY

IRB Administration Office
87 East Canfield, Second Floor
Detroit, Michigan 48201
Phone: (313) 577-1628
FAX: (313) 993-7122
http://lrb.wayne.edu

CONCURRENCE OF EXEMPTION

To: Donna Bell
Industrial and Systems Engineering

From: For Dr. Deborah Ellis M. Tanzer, MD/BC
Chairperson, Behavioral Institutional Review Board (B3)

Date: March 06, 2018

RE: IRB #: 012818B3X

Protocol Title: Understanding the Relationship of Innovation and Quality in a Fast Changing Market: An Automotive Perspective

Sponsor:

Protocol #: 1801001121

The above-referenced protocol has been reviewed and found to qualify for **Exemption** according to paragraph #7 of the Department of Health and Human Services Code of Federal Regulations [45 CFR 46.101(b)].

- Revised Social/Behavioral/Education Exempt Protocol Summary Form (revision received in IRB Office 01/17/2018)
- Research Protocol dated December 2017(received in the IRB Office 01/09/2018)
- Medical records are not being accessed therefore HIPAA does not apply.
- Research Informed Consent (revision dated 12/12/2017)
- Recruitment Letter
- Proposed Interview Questions
- Data Collection Tool (1): (I) Online Survey with Information Sheet

This proposal has not been evaluated for scientific merit, except to weigh the risk to the human subjects in relation to the potential benefits.

- Exempt protocols do not require annual review by the IRB.
- All changes or amendments to the above-referenced protocol require review and approval by the IRB **BEFORE** implementation.
- Adverse Reactions/Unexpected Events (AR/UE) must be submitted on the appropriate form within the timeframe specified in the IRB Administration Office Policy (http://irb.wayne.edu/policies-human-research.php).

NOTE: Forms should be downloaded from the IRB Administration Office website http://irb.wayne.edu at each use.

Notify the IRB of any changes to the funding status of the above-referenced protocol.

APPENDIX C: INTERVIEW TEMPLATE WITH QUESTIONS

Interview ID (AA_ddmmyy_interviewerinitials_eventnumber, e.g. AA_180612_JG_01): _____
Date: _____ Time (24hr): Fr: _____ To: _____
Interviewee (FN LN): _____
Interviewer Initials: _____ Location: _____

Introduction
Hello, my name is Donna Bell. I am with a PhD candidate from Wayne State University and also an employee in the Research and Advanced organization at Ford. I'm currently doing research to understand current team dynamics and their implications for the organization – and on developing better processes and approaches for working as a team on fast-to-market advanced product designs. I appreciate your making the time available for me to ask you some questions.

The goal of this interview is to learn your perspective on how engineers working in fast-to-market advanced product design and those working in quality understand each other, if they share the same organizational culture, and if their interdepartmental interactions impact the output of advanced product designs. I encourage you to be as open and candid with me as possible. I will keep your responses strictly confidential. I will be interviewing multiple people within your firm. I will be looking for general themes across the interviews, and we will summarize the results without identifying anyone specifically.

With your permission, I would like to record this interview to help me with my note taking. Recordings will not be shared with anyone at The Company. Please feel free at any time to ask me to stop the recorder if you want to say something that you do not wish to be recorded. Is that all right with you?

Do you have any questions before we begin?
1. First, can you describe or me your role in Ford? Not just your job title, but what you do.
2. What is your definition of Quality?
3. What is your definition of Innovation?
4. What do you think the corporate strategy is for innovation?
5. What do you think the corporate strategy is for quality?
6. How do you believe innovation and quality can be achieved together?
    a. How do you think it works now?

7. What culture do you believe is necessary to deliver both innovation and quality together?
8. Is there anything else that you would like to tell me about this topic that I have not asked you?
9. What other people can I interview in your organization?

APPENDIX D: QUALITY AND INNOVATION SURVEY

Quality and Innovation Survey
To: US-Based employees
Date: July 9, 2019

The following survey is being conducted to study the dynamics of quality and innovation within a mature firm. The survey contains questions about innovation, quality, and their intersection, organizational culture, organizational structure and networks, information exchange, and interdepartmental interactions. Data from this research are intended to inform management about the ways to deal with the challenges of introducing fast-to-market technologies and innovations during the advanced product design process, while ensuring a positive impact on product quality. All completed surveys are strictly confidential. Only aggregated data will be analyzed to understand the general themes perceived by technical professionals.

I'm looking for about 200 engineers, scientists, and researchers in R&A, PD, and Quality to take the survey. It should take about 15 minutes to complete and is easier to take on a computer. The goal is to have all survey responses in by **Wednesday, July 31, 2019**.

If you have any questions about this study now or in the future, you may contact Donna Bell (donna.bell@wayne.edu) at (313)805-4028. If you have questions or concerns about your rights as a research participant, the Chair of the Human Investigation Committee at Wayne State can be contacted at (313) 577-1628.

Thank you in advance for your participation in this study.

Q1 Thank you for agreeing to participate in our research study. You have been identified as a participant for this survey because YOU: 1) are a US-based firm engineering/technical professional by formal education, experience, or training; **and** 2) have at least one experience as an advanced product design professional, or as a quality professional from the corporate quality organization or both that has worked on fast-to-market technology. Note: Advanced product design refers to designs that are created by a technical team that are intended for fast to market introduction. Another name for advanced product design is conceptual design. Do all of the above conditions apply to you?

- ○ Yes
- ○ No

Skip To: End of Survey If Thank you for agreeing to participate in our research study. You have been identified as a parti… = No

Q2 What is your current work area?

- ○ Quality
- ○ Advanced Product Design
- ○ Other – Please specify _____

Q3 Of the two areas, quality and advanced product design, which area have you had experience in?

- ○ Quality
- ○ Advanced Product Design
- ○ Both

Q4 With respect to Advanced Product Design and Quality; How long were you in the position?

- ☐ Quality (years) _____
- ☐ Advanced Product Design (years) _____

Q5 How long have you worked at the company?

- ☐ 1 – 5 Years
- ☐ 5 – 10 years
- ☐ 10 – 20 years
- ☐ 20+ years

Q6 What area are/were you associated with as a Quality professional?

- ☐ Body Design (Interior or Exterior)
- ☐ Powertrain
- ☐ Electrical and Electronics
- ☐ Chassis
- ☐ Vehicle Engineering
- ☐ Other; Please specify _____
- ☐ Not Applicable

Q7 What area are/were you associated with as an Advanced Product Design engineer?

- ☐ Body Design (Interior or Exterior)
- ☐ Powertrain
- ☐ Electrical and Electronics
- ☐ Chassis
- ☐ Vehicle Engineering
- ☐ Other; Please specify_____
- ☐ Not Applicable

Q8 What is/was the primary company facility at which you are/were based? Choose only one.

- ○ US – Dearborn, MI
- ○ US – Palo Alto
- ○ Other; Please specify _____

Q9.

We invite you to take time to complete this survey for the organization you are/were associated with during a time when you worked on a fast-to-market technology.

This survey is designed to understand the cultural, organizational, communications, and performance (both quality and innovation) aspects of the company as it relates to fast-to-market technologies.

The first section is related to culture. Each question should be assessed twice; once for **NOW** and once for **PREFERRED**.
NOW refers to the actual operation of the organization during the time the fast-to-market technology was being developed.
PREFERRED refers to how you believe the organization should operate or should have operated during the time of the fast-to-market technology development.

Rate the organization from Strongly Disagree to Strongly Agree for **NOW** . Then answer the same question in the next section based on how you believe the organization "should" operate **(PREFERRED).**

	NOW					PREFERRED				
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The organization defines success on the basis of efficiency. Dependable delivery, smooth scheduling, and low-cost productions are critical.	○	○	○	○	○	○	○	○	○	○
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The organization is a very personal place. It is like an extended family. People seem to share a lot of themselves.	○	○	○	○	○	○	○	○	○	○
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The glue that holds the organization together is commitment to innovation and development. There is an emphasis on being on the cutting edge.	○	○	○	○	○	○	○	○	○	○
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The management style in the organization is characterized by teamwork, consensus, and participation.	○	○	○	○	○	○	○	○	○	○
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The leadership in the organization is generally considered to exemplify mentoring, facilitating, or nurturing.	○	○	○	○	○	○	○	○	○	○
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The organization defines success on the basis of the development of human resources, teamwork, employee commitment, and concern for people.	○	○	○	○	○	○	○	○	○	○
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The organization emphasizes acquiring new resources and creating new challenges. Trying new things and prospecting for opportunities are valid.	○	○	○	○	○	○	○	○	○	○
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The management style in the organization is characterized by individual risk taking, innovation, freedom, and uniqueness.	○	○	○	○	○	○	○	○	○	○
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The organization is a dynamic and entrepreneurial place. People are willing to stick their necks out and take risks.	○	○	○	○	○	○	○	○	○	○
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The glue that holds the organization together is loyalty and mutual trust. Commitment to this organization runs high.	○	○	○	○	○	○	○	○	○	○

	NOW					PREFERRED				
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The organization is a very controlled and structured place. Formal procedures generally govern what people do.	○	○	○	○	○	○	○	○	○	○
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The organization defines success on the basis of having unique or the newest products. It is a product leader and innovator.	○	○	○	○	○	○	○	○	○	○
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The organization emphasizes competitive actions and achievements. Hitting stretch targets and winning in the marketplace are dominant.	○	○	○	○	○	○	○	○	○	○
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The leadership in the organization is generally considered to exemplify entrepreneurship, innovation, or risk taking.	○	○	○	○	○	○	○	○	○	○
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The organization is very results oriented. A major concern is with getting the job done. People are very competitive and achievement oriented.	○	○	○	○	○	○	○	○	○	○
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The management style in the organization is characterized by security of employment, conformity, predictability, and stability in relationships.	○	○	○	○	○	○	○	○	○	○
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The organization defines success on the basis of winning in the marketplace and outpacing the competition.	○	○	○	○	○	○	○	○	○	○
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The glue that holds the organization together is formal rules and policies. Maintaining a smoothly running organization is important.	○	○	○	○	○	○	○	○	○	○
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The leadership in the organization is generally considered to exemplify coordinating, organizing, or smooth-running efficiency.	○	○	○	○	○	○	○	○	○	○
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The organization emphasizes permanence and stability. Efficiency, control, and smooth operations are important.	○	○	○	○	○	○	○	○	○	○

	NOW					PREFERRED				
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The leadership in the organization is generally considered to exemplify a no-nonsense, aggressive, results-oriented focus.	○	○	○	○	○	○	○	○	○	○
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The management style in the organization is characterized by hard-driving competitiveness, high demands, and achievement.	○	○	○	○	○	○	○	○	○	○
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The glue that holds the organization together is the emphasis on achievement and goal accomplishment.	○	○	○	○	○	○	○	○	○	○
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The organization emphasizes human development. High trust, openness, and participation persist.	○	○	○	○	○	○	○	○	○	○
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Q10. For this portion of the survey, please read the question and assess the questions based on your experience during the development of the fast-to-market technology.

To what extent do you agree with the following items describing your organization's interdepartmental interactions and communication. Each question should be rated from Strongly disagree to Strongly agree.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Junior managers in my department can easily schedule meetings with junior managers in other departments.	○	○	○	○	○
Communications from one department to another are expected to be routed through “proper channels”.	○	○	○	○	○
Managers here discourage employees from discussing work related matters with those who are not their immediate supervisors or subordinates.	○	○	○	○	○
In this business unit, employees from different departments feel comfortable calling each other when the need arises.	○	○	○	○	○
There is ample opportunity for informal “hall talk” among individuals from different departments in this business unit.	○	○	○	○	○

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
In this business unit it is easy to talk with virtually anyone you need to, regardless of rank or position.	○	○	○	○	○
There is little or no interdepartmental conflict in this business unit.	○	○	○	○	○
The objectives pursued by the marketing department are incompatible with those of the manufacturing department.	○	○	○	○	○
Protecting one's departmental turf is considered to be a way of life in this business unit.	○	○	○	○	○
Employees from different departments feel that the goals of their respective departments are in harmony with each other.	○	○	○	○	○
People in one department generally dislike interacting with those from another department.	○	○	○	○	○
When members of several departments get together, tensions frequently run high.	○	○	○	○	○
Most departments in this business get along well with each other.	○	○	○	○	○

Q11. For this portion of the survey, please read the question and assess the questions based on your experience during the development of the fast-to-market technology.

To what extent do you agree with the following items describing your organization's information exchange and fast-to-market technology performance. Each question should be assessed from Strongly Disagree to Strongly Agree.

	Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither Disagree or Agree	Slightly Agree	Moderately Agree	Strongly Agree
Our product introduces many completely new features to this class of products.	○	○	○	○	○	○	○
We are encouraged to share our expertise with other areas.	○	○	○	○	○	○	○
Our product is highly innovative, replacing an inferior alternative.	○	○	○	○	○	○	○
We share information in my organization.	○	○	○	○	○	○	○
Compared to similar products developed by our organization, our product will offer unique features/attributes/benefits to the customers.	○	○	○	○	○	○	○

We exchange ideas with employees from different areas.	○	○	○	○	○	○	○
The quality of our products and services is better than that of our major competitors.	○	○	○	○	○	○	○
Compared to similar products developed by our competitors, our product will offer unique features/attributes/benefits to the customers.	○	○	○	○	○	○	○
Information is communicated in my organization.	○	○	○	○	○	○	○
Our customers are firmly convinced that we offer very good quality products.	○	○	○	○	○	○	○
Our product incorporates a radically new technological knowledge.	○	○	○	○	○	○	○
Our customers often praise our product quality.	○	○	○	○	○	○	○
High quality technical innovations were introduced during the development of this product.	○	○	○	○	○	○	○

Q12 In the space provided below, please provide in your own words what we are doing to impact both quality and innovation performance?

Q13 In the space below, please provide in your own words the definition of QUALITY

Q14 In the space below, please provide in your own words the definition of INNOVATION

Q15 Please tell us a little about your background… Are you (choose only one)

- ○ Female
- ○ Male

Q16 Years of experience in engineering / technical capacity (choose only one)

- ○ 2 or more but less than 5
- ○ 5 or more but less than 10
- ○ 10 or more but less than 20
- ○ 20 or ore but less than 30
- ○ 30 or more

Q17 Please select your current organizational role below:

- ○ Non-management Engineer
- ○ Supervisor or Technical Specialist
- ○ Manager or Chief Engineer
- ○ Director
- ○ Vice President

Q18 Highest educational degree (choose only one)

- ○ No post-secondary degree
- ○ Associates or technical certification
- ○ Bachelor's
- ○ Graduate Degrees
- ○ Professional Degrees (e.g. JD, MD, etc.)
- ○ Other; please specify_____

Q19 If you would like a summary of the results, please indicate your name and e-mail (or mailing) address below to receive a copy. This is strictly voluntary. Your identity will remain totally confidential.

APPENDIX E: OPERATIONAL ITEMS TO MEASURE STUDY CONSTRUCTS

Construct: *COMPETING VALUES FRAMEWORK (CULTURE)*	**Dimension:** *CLAN*	**Item IDs:** *CVF_X_A1 - CVF_X_A6**
CVF_X_A1	Dominate Characteristic - The organization is a very personal place. It is like an extended family. People seem to share a lot of themselves.	
CVF_X_A2	Organizational Leadership - The leadership in the organization is generally considered to exemplify mentoring, facilitating, or nurturing.	
CVF_X_A3	Management of Employees - The management style in the organization is characterized by teamwork, consensus, and participation.	
CVF_X_A4	Organizational Glue - The glue that holds the organization together is loyalty and mutual trust.	
CVF_X_A5	Strategic Emphasis - The organization emphasizes human development. High trust, openness, and participation persist.	
CVF_X_A6	Criteria of Success - The organization defines success on the basis of the development of human resources, teamwork, employee commitment, and concern for people.	

* X = N (NOW) *or* P (PREFERRED)

Construct: *COMPETING VALUES FRAMEWORK (CULTURE)*	**Dimension:** *ADHOCRACY*	**Item IDs:** *CVF_X_B1 - CVF_X_B6**
CVF_X_B1	Dominate Characteristic - The organization is a dynamic an entrepreneurial place. People are willing to stick their necks out and take risks.	
CVF_X_B2	Organizational Leadership - the leadership in the organization is generally considered to exemplify entrepreneurship, innovation, or risk taking.	
CVF_X_B3	Management of Employees - The management style in the organization is characterized by individual risk taking, innovation, freedom, and uniqueness.	
CVF_X_B4	Organizational Glue - The glue that holds the organization together is commitment to innovation and development. there is an emphasis on being on the cutting edge.	
CVF_X_B5	Strategic Emphasis - The organization emphasizes acquiring new resources and creating new challenges. Trying new things and prospecting for opportunities are valid.	
CVF_X_B6	Criteria of Success - The organization defines success on the basis of having unique or the newest products. It is a product leader and innovator.	

* X = N (NOW) *or* P (PREFERRED)

Construct: *COMPETING VALUES FRAMEWORK (CULTURE)*	**Dimension:** *MARKET*	**Item IDs:** *CVF_X_C1 - CVF_X_C6**
CVF_X_C1	Dominate Characteristic: The organization is very results oriented. A major concern is with getting the job done. People are very competitive and achievement oriented.	
CVF_X_C2	Organizational Leadership: The leadership in the organization is generally considered to exemplify a non-nonsense, aggressive, results-oriented focus.	
CVF_X_C3	Management of Employees: The management style in the organization is characterized by hard-driving competitiveness, high demands, and achievement.	
CVF_X_C4	Organizational Glue: The glue that holds the organization together is the emphasis on achievement and goal accomplishment.	
CVF_X_C5	Strategic Emphasis: The organization emphasizes competitive actions and achievements. Hitting stretch targets and winning in the marketplace are dominant.	
CVF_X_C6	Criteria of Success: the organization defines success on the basis of winning in the marketplace and outpacing the competition.	

* X = N (NOW) *or* P (PREFERRED)

Construct: *COMPETING VALUES FRAMEWORK (CULTURE)*	**Dimension:** *HIERARCHY*	**Item IDs:** *CVF_X_D1 - CVF_X_D6**
CVF_X_D1	Dominate Characteristic: the organization is a very controlled and structured place. Formal procedures generally govern what people do.	
CVF_X_D2	Organizational Leadership: the leadership in the organization is generally considered to exemplify coordinating, organizing, or smooth-running efficiency.	
CVF_X_D3	Management of Employees: The management style in the organization is characterized by security of employment, conformity, predictability, and stability in relationships.	
CVF_X_D4	Organizational Glue: The glue that holds the organization together is formal rules and policies. Maintaining a smoothly running organization is important.	
CVF_X_D5	Strategic Emphasis: the organization emphasizes permanence and stability. Efficiency, control, and smooth operations are important.	
CVF_X_D6	Criteria of Success the organization defines success on the basis of efficiency. Dependable delivery, smooth scheduling, and low-cost productions are critical.	

* X = N (NOW) *or* P (PREFERRED)

Construct: *INFORMATION EXCHANGE*	Item IDs: INEX_1 - INEX_4
INEX_1	Information is communicated in my organization.
INEX_2	We share information in my organization.
INEX_3	We exchange ideas with employees from different areas.
INEX_4	We are encouraged to share are expertise with other areas.

Construct: *INTERDEPARTMENTAL INTERACTIONS*	**Dimension:** *INTERDEPARTMENTAL CONNECTEDNESS*	**Item IDs:** *CONN_1 - CONN_7*
CONN_1	In this business unit it is easy to talk with virtually anyone you need to, regardless of rank or position.	
CONN_2	There is ample opportunity for informal "hall talk" among individuals from different departments in this business unit.	
CONN_3	In this business unit, employees from different departments feel comfortable calling each other when the need arises.	
CONN_4*	Managers here discourage employees from discussing work related matters with those who are not their immediate supervisors or subordinates.	
CONN_5**	People around here are quite accessible to those in other departments.	
CONN_6*	Communications from one department to another are expected to be routed through "proper channels".	
CONN_7	Junior managers in my department can easily schedule meetings with junior managers in other departments.	

* Reverse coded question
**Question Removed from survey

Construct: *INTERDEPARTMENTAL INTERACTIONS*	**Dimension:** *INTERDEPARTMENTAL CONFLICT*	**Item IDs:** *CONF_1 - CONF_7*
CONF_1*	Most departments in this business get along well with each other.	
CONF_2	When members of several departments get together, tensions frequently run high.	
CONF_3	People in one department generally dislike interacting with those from another department.	
CONF_4*	Employees from different departments feel that the goals of their respective departments are in harmony with each other.	
CONF_5	Protecting one's departmental turf is considered to be a way of life in this business unit.	
CONF_6	The objectives pursued by the marketing department are incompatible with those of the manufacturing department.	
CONF_7*	There is little or no interdepartmental conflict in this business unit.	

* Reverse coded question
**Question Removed from survey

Construct: *ADVANCED PRODUCT DESIGN PERFORMANCE*	**Item IDs:** *APD_1 - APD_6*	
APD_1	High quality technical innovations were introduced during the development of this product.	
APD_2	Compared to similar products developed by our competitors, our product will offer unique features/attributes/benefits to the customers.	
APD_3	Our product introduces many completely new features to this class of products.	
APD_4	Compared to similar products developed by our organization, our product will offer unique features/attributes/benefits to the customers.	
APD_5	Our product is highly innovative, replacing an inferior alternative.	
APD_6	Our product incorporates a radically new technological knowledge.	

Construct: *QUALITY PERFORMANCE*	**Item IDs:** *QUAL_1 - QUAL_3*	
QUAL_1	Our customers often praise our product quality.	
QUAL_2	The quality of our products and services is better than that of our major competitors.	
QUAL_3	Our customers are firmly convinced that we offer very good quality products.	

APPENDIX F: EFA DESCRIPTIVE STATISTICS AND PATTERN MATRICES

N = 308		Standard err of skewness = 0.139			
	Mean	Median	SD	Skewness	Level of Skewness
APD_1	4.87	5.00	1.408	-0.634	Moderate
APD_2	5.05	5.00	1.367	-0.668	Moderate
APD_3	5.05	5.00	1.496	-0.712	Moderate
APD_4	5.36	6.00	1.308	-0.882	Moderate
APD_5	4.88	5.00	1.431	-0.58	Moderate
APD_6	4.27	4.00	1.636	-0.295	
CONF_1R	2.20	2.00	0.94	0.818	Moderate
CONF_2	2.29	2.00	1.115	0.539	Moderate
CONF_3	2.25	2.00	1.045	0.595	Moderate
CONF_4R	3.09	3.00	0.98	0.012	
CONF_5	3.04	3.00	1.112	-0.192	
CONF_6	3.16	3.00	0.889	-0.031	
CONF_7R	3.00	3.00	1.12	0.104	
CONN_1	3.56	4.00	1.197	-0.647	Moderate
CONN_2	3.53	4.00	1.206	-0.534	Moderate
CONN_3	4.13	4.00	0.917	-1.173	Highly
CONN_4R	3.90	4.00	1.038	-0.805	Moderate
CONN_6R	2.64	2.00	1.157	0.444	
CONN_7	3.88	4.00	1.028	-0.807	Moderate
CVF_N_A1	3.21	3.00	0.961	-0.345	
CVF_N_A2	2.97	3.00	1.060	-0.173	
CVF_N_A3	3.28	3.00	0.993	-0.430	
CVF_N_A4	3.06	3.00	1.001	-0.144	
CVF_N_A5	2.91	3.00	1.08	0.032	
CVF_N_A6	2.86	3.00	1.011	-0.053	
CVF_N_B1	2.32	2.00	1.000	0.500	
CVF_N_B2	2.67	3.00	0.945	0.006	
CVF_N_B3	2.66	3.00	1.011	0.198	
CVF_N_B4	2.98	3.00	1.019	-0.122	
CVF_N_B5	3.09	3.00	1.014	-0.372	
CVF_N_B6	2.87	3.00	1.027	-0.034	
CVF_N_C1	3.56	4.00	0.934	-0.485	
CVF_N_C2	3.24	3.00	0.992	-0.296	
CVF_N_C3	3.29	3.00	0.961	-0.238	
CVF_N_C4	3.41	4.00	0.888	-0.498	
CVF_N_C5	3.37	4.00	0.969	-0.482	

N = 308		Standard err of skewness = 0.139			
	Mean	Median	SD	Skewness	Level of Skewness
CVF_N_C6	3.45	4.00	1.002	-0.617	Moderate
CVF_N_D1	3.61	4.00	1.075	-0.606	Moderate
CVF_N_D2	3.10	3.00	0.996	-0.23	
CVF_N_D3	3.28	3.00	1.050	-0.433	
CVF_N_D4	3.56	4.00	0.927	-0.735	Moderate
CVF_N_D5	3.34	4.00	0.968	-0.41	
CVF_N_D6	3.43	4.00	1.058	-0.493	
CVF_P_A1	4.00	4.00	0.733	-0.554	Moderate
CVF_P_A2	4.38	4.00	0.622	-1.142	Highly
CVF_P_A3	4.43	4.00	0.613	-1.08	Highly
CVF_P_A4	4.24	4.00	0.67	-0.841	Moderate
CVF_P_A5	4.22	4.00	0.594	-0.577	Moderate
CVF_P_A6	4.20	4.00	0.709	-0.868	Moderate
CVF_P_B1	4.05	4.00	0.72	-0.91	Moderate
CVF_P_B2	4.03	4.00	-0.672	-0.811	Moderate
CVF_P_B3	4.10	4.00	0.72	-0.675	Moderate
CVF_P_B4	4.39	4.00	0.683	-1.107	Highly
CVF_P_B5	4.30	4.00	0.617	-0.801	Moderate
CVF_P_B6	4.18	4.00	0.781	-1.026	Highly
CVF_P_C1	3.94	4.00	0.774	-0.7	Moderate
CVF_P_C2	3.62	4.00	0.855	-0.578	Moderate
CVF_P_C3	3.60	4.00	0.843	-0.638	Moderate
CVF_P_C4	3.89	4.00	0.701	-0.694	Moderate
CVF_P_C5	4.13	4.00	0.715	-0.788	Moderate
CVF_P_C6	4.12	4.00	0.714	-0.882	Moderate
CVF_P_D1	3.30	3.00	0.997	-0.357	
CVF_P_D2	3.88	4.00	0.659	-0.688	Moderate
CVF_P_D3	3.45	3.00	0.935	-0.161	
CVF_P_D4	3.41	4.00	0.928	-0.418	
CVF_P_D5	3.70	4.00	0.8	-0.446	
CVF_P_D6	4.18	4.00	0.848	-1.312	Highly
INEX_1	5.01	5.00	1.536	-0.788	Moderate
INEX_2	5.38	6.00	1.46	-1.103	Highly
INEX_3	5.01	5.00	1.61	-0.793	Moderate
INEX_4	5.10	5.00	1.498	-0.805	Moderate
QUAL_1	4.72	5.00	1.258	-0.515	Moderate
QUAL_2	4.85	5.00	1.419	-0.534	Moderate
QUAL_3	4.74	5.00	1.341	-0.515	Moderate

APPENDIX G: EFA CORRELATION AND PATTERN MATRICES

Factor Correlation Matrix – NOW

Factor Correlation Matrix

Factor	1	2	3	4	5	6	7	8	9
1	1.000	.459	.412	.247	.271	.466	.255	.487	.377
2	.459	1.000	.485	.470	.366	.642	.268	.271	.464
3	.412	.485	1.000	.535	.170	.376	.056	.252	.370
4	.247	.470	.535	1.000	.145	.360	.048	.239	.328
5	.271	.366	.170	.145	1.000	.367	.324	.302	.328
6	.466	.642	.376	.360	.367	1.000	.068	.170	.333
7	.255	.268	.056	.048	.324	.068	1.000	.171	.264
8	.487	.271	.252	.239	.302	.170	.171	1.000	.337
9	.377	.464	.370	.328	.328	.333	.264	.337	1.000

Extraction Method: Principal Axis Factoring.
Rotation Method: Promax with Kaiser Normalization.

Factor Correlation Matrix – PREFERRED

Factor Correlation Matrix

Factor	1	2	3	4	5	6	7	8	9
1	1.000	.317	-.048	.490	.327	.089	.221	.174	.264
2	.317	1.000	-.270	.270	.180	.425	.462	.471	.168
3	-.048	-.270	1.000	-.007	-.041	-.547	-.499	-.235	-.035
4	.490	.270	-.007	1.000	.350	.139	.124	.085	.365
5	.327	.180	-.041	.350	1.000	.213	.013	-.015	-.049
6	.089	.425	-.547	.139	.213	1.000	.536	.275	.032
7	.221	.462	-.499	.124	.013	.536	1.000	.389	.015
8	.174	.471	-.235	.085	-.015	.275	.389	1.000	.002
9	.264	.168	-.035	.365	-.049	.032	.015	.002	1.000

Extraction Method: Principal Axis Factoring.
Rotation Method: Promax with Kaiser Normalization.

Pattern Matrix – NOW

Pattern Matrix									
	Factor								
	1	2	3	4	5	6	7	8	9
APD_6	0.864								
APD_4	0.864								
APD_5	0.833								
APD_3	0.825								
APD_2	0.739								
APD_1	0.66								
QUAL_2	0.395							0.317	
CVF_N_A5		0.772							
CVF_N_A4		0.765							
CVF_N_A2		0.735							
CVF_N_A3		0.718							
CVF_N_A6		0.699							
CVF_N_D2		0.573					0.221		
CVF_N_A1		0.441							
CONN_3			0.74						
CONN_1		0.291	0.603						
CONN_7			0.599						
CONN_2			0.532						
CONF_7R			-0.319	-0.279					
CONF_2				-0.889					
CONF_3				-0.77					
CONF_1R			-0.266	-0.528					
CONF_6			0.289	-0.441					
CONF_4R				-0.426					
CONF_5		-0.248		-0.418			0.3		-0.221
CVF_N_C3					0.835				
CVF_N_C2					0.698				
CVF_N_C1					0.623				
CVF_N_C5					0.449	0.223			
CVF_N_C4		0.323		-0.269	0.341				
CVF_N_D6		0.222			0.231				
CVF_N_B6						0.73			
CVF_N_B4						0.657			
CVF_N_B5						0.627			
CVF_N_B2		0.341				0.521			
CVF_N_C6					0.372	0.493			
CVF_N_B3		0.327				0.483			
CVF_N_B1		0.389				0.409			
CVF_N_D4							0.729		
CVF_N_D1							0.618		
CVF_N_D3							0.572		
CVF_N_D5		0.289					0.566		
QUAL_3								0.769	
QUAL_1	0.227							0.746	
INEX_2			0.221						0.631
INEX_3			0.322		-0.203				0.588
INEX_1									0.464
INEX_4	0.21		0.214						0.316
CONN_4R	-0.207		0.308						0.315
Extraction Method: Principal Axis Factoring.									
Rotation Method: Promax with Kaiser Normalization.									
Rotation converged in 10 iterations.[a]									

Pattern Matrix – PREFERRED

Pattern Matrix									
	Factor								
	1	2	3	4	5	6	7	8	9
CVF_P_A2	0.739								
CVF_P_A6	0.71			-0.208	0.254				
CVF_P_A3	0.687								
CVF_P_A4	0.615								
CVF_P_A5	0.612								
CVF_P_B3	0.579								0.248
CVF_P_B1	0.511				-0.207				0.25
CVF_P_B5	0.499								0.376
CVF_P_B4	0.445								0.438
CVF_P_D6	0.41				0.258				
CVF_P_A1	0.396								
CVF_P_B2	0.394			0.235					0.244
APD_6		0.905							
APD_3		0.843							
APD_5		0.805							
APD_4		0.783							
APD_1		0.697							
APD_2		0.688							-0.215
QUAL_2		0.384						0.334	
CONF_2			0.934						
CONF_3			0.747						
CONF_1R			0.639						
CONF_4R			0.497						
CONF_5			0.469						
CONF_7R			0.417			-0.283			
CONF_6			0.396			0.253			
CVF_P_C3				0.768					
CVF_P_C2				0.621					
CVF_P_C4				0.574		0.203			
CVF_P_C1				0.558					
CVF_P_C6				0.546					
CVF_P_C5	0.218			0.524					
CVF_P_D4					0.764				
CVF_P_D1					0.759				
CVF_P_D5					0.665				
CVF_P_D2	0.253				0.488				
CVF_P_D3					0.415				
CONN_3						0.742			
CONN_1						0.608			
CONN_7						0.606			
CONN_2						0.566			
CONN_4R		-0.207				0.357			
INEX_2							0.868		
INEX_1							0.623		
INEX_3							0.612		
INEX_4							0.419		
QUAL_3								0.823	
QUAL_1		0.274						0.718	
CVF_P_B6	0.296								0.556
Extraction Method: Principal Axis Factoring.									
Rotation Method: Promax with Kaiser Normalization.a									
a Rotation converged in 10 iterations.									

APPENDIX H: INTERVIEW DEMOGRAPHICS

Gender		
	Female	Male
Count	5	15
Percentage	25%	75%

Interview Method		
	Scribed	Recorded
Count	14	6
Percentage	70%	30%

Past Reporting Organization			
	Quality	Conceptual Design	Hybrid
Count	4	9	7
Percentage	20%	45%	35%

Category				
	Manager	Chief Engineer	Director	Vice President
Count	3	3	9	5
Percentage	15%	15%	45%	25%

APPENDIX J: SAMPLE DEMOGRAPHICS

What is your Current Work Area?				
	Quality	Advanced Product Design	Other	Total
Count	49	197	68	314
Percentage	15.61%	62.74%	21.66%	

What Areas have you had experience in?				
	Quality	Advanced Product Design	Both	Total
Count	40	169	105	314
Percentage	12.74%	53.82%	33.44%	

How long were you in the position?		
	Quality	Advanced Product Design
1 - 10 Years	103	145
11 - 20 years	27	71
21 - 30 years	11	46
30+ years	1	5

How long have you worked at the company?			
	1 - 10 years	10 - 20 years	20+ years
Count	124	75	116
Percentage	39%	23.80%	36.83%

What area were you associated with as a quality professional?							
	Body Design	Powertrain	Electrical/ Electronics	Chassis	Vehicle Engineering	Other	Not Applicable
Count	51	37	72	25	23	40	122
Percentage	13.78%	10%	19.46%	6.76%	6.22%	10.81%	32.97%

What area were you associated with as and advanced product design engineer?							
	Body Design	Powertrain	Electrical/ Electronics	Chassis	Vehicle Engineering	Other	Not Applicable
Count	79	63	120	36	16	30	30
Percentage	21.12%	16.84%	32.09%	9.63%	4.28%	8.02%	8.02%

What is/was the primary company US facility at which you are/were based?			
	Detroit Area	Northern California	Other
Count	290	10	14
Percentage	92.36%	3.18%	4.46%

Gender		
	Female	Male
Count	61	244
Percentage	20%	80%

Years of experience in engineering/technical capacity				
	2 - 9 Years	10 - 19 years	20 - 29 years	30+ years
Count	67	69	117	59
Percentage	21.47%	22.12%	37.50%	18.91%

Current Organizational Role					
	Non-Management;Engineer	Supervisor or Technical Specialist	Manager or Chief Engineer	Director	Vice President
Count	174	89	40	6	0
Percentage	56.31%	28.80%	12.94%	1.94%	0%

Highest Educational Degree						
	No post secondary degree	Associates or Technical Certification	Bachelor's	Graduate Degrees	Professional Degrees (e.g. JD, MD, etc.)	Other
Count	1	3	93	193	12	10
Percentage	0.32%	0.96%	29.81%	61.86%	3.85%	3.21%

APPENDIX K: WORDIJ, LIWC, AND ATLAS.TI OUTPUTS

Manager Analysis Details

Word Frequency

WORD	FREQUENCY
quality	74
think	59
not	41
innovation	39
new	22
time	22
things	22
deliver	21
customer	19
ford	18
really	18
people	18
culture	18
work	17

Opticomm Output

Initial Output:

[Distance] path (Average pair frequency)

Strings with low average pair frequency:
[0.1250] innovation -> quality (8.0000)

Strings with high average pair frequency:
[0.1250] innovation -> quality (8.0000)

All paths
[0.1250] innovation -> quality (8.0000)

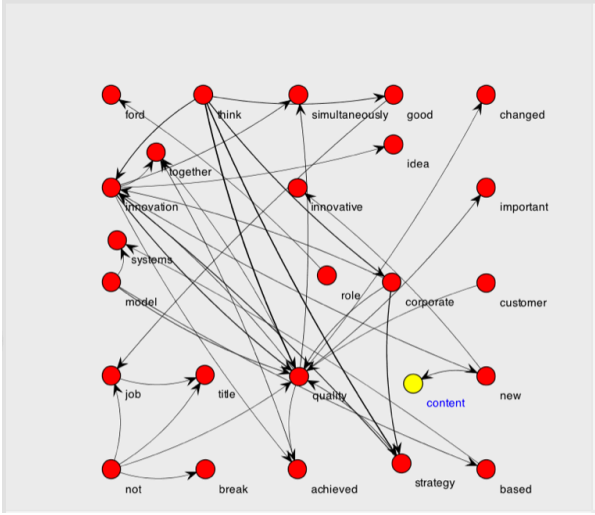
Improved Output:

[Distance] path (Average pair frequency)

Strings with low average pair frequency:
[1.5000] innovation -> have -> quality (1.5000)
[1.5000] innovation -> with -> quality (1.5000)
[2.0000] innovation -> a -> quality (1.0000)
[2.0000] innovation -> work -> quality (1.0000)

Strings with high average pair frequency:
[0.1429] innovation -> quality (7.0000)
[0.2000] innovation -> and -> quality (10.0000)
[0.2476] innovation -> the -> quality (13.0000)
[0.3429] innovation -> is -> quality (6.0000)

VISij Output – Managers



QAPnet Output – Managers

	Interview Code Number		
	8	7	31
8		-0.639	-0.731
7			-0.665
31			

LIWC – Managers Positivity Index

compare	interrog	number	quant	affect	posemo	negemo	Positivity Index	anx
2.75	1.95	1.46	2.56	3.89	3.35	0.50	6.70	0.19

APPENDIX K: OTHER LEADERSHIP LEVEL QUALITATIVE ANALYSIS

Chief Engineer		
Tool/Function	**Output**	**Insight**
WORDij/ WordLink	The word "think" and "quality" are the most used words, with the words "don't" and "not" in the third and fourth position, respectively.	Suggests the interviews were more negative than positive. This is confirmed with the LIWC results.
LIWC	LIWC Positivity Index Score of 3.79	Shows the interviews in the Chief category were less positive than those in the manager category (6.7), however, they were more positive than the directors (2.3) and vice presidents (1.85)
WORDij/ OptiComm	Strings with low average pair frequency: [0.4500] innovation -> way -> quality (4.500) Strings with high average pair frequency: [0.1111] innovation -> quality (4.5000) All Paths: [0.1111] innovation -> quality (4.5000) [0.4500] innovation -> way -> quality (4.500)	This could be interpreted as "Innovation is the way to quality"
z-Test	Chief engineers mention words *experience* and *change* more often than directors with z-scores of 3.726 ($\chi 2$ = 3.125) and 4.929 ($\chi 2$ = 9.143) respectively. Chief engineers mention words *cost*, *people*, and *now* more often the vice presidents with z-scores of 0.6969 (*), 1.298 (($\chi 2$ = 14.534), and 1.627 (*), respectively. *$\chi 2$ = N/A, comparator frequency less than 5.	Chief engineers are more concerned with experience and change when it comes to innovation and quality as compared to directors. Chief engineers are more concerned with cost, people and what's happening now as compared to vice presidents. Both confirming the tactical point of view of the chief engineers relative to those that are senior to them.
Atlas.ti / Key Quotes	*"So, the ability to take an idea, move it into a product, and improving the functionality or quality of a certain product. That's innovation."* *"There is trial and error, fail fast. Can't have a culture that penalizes people for failure."* *"Ok [culture] is changing and I'm trying to be part of that change to be a change agent to help that, but you can see it's changing"*	

Director		
Tool/Function	**Output**	**Insight**
WORDij/ WordLink	The words *"quality"* and *"innovation"* are the most used words, with the words *"not"* and *"don't"* in the fourth and fifth position, respectively.	Directors mention quality and innovation more often than other groups. This could suggest that these corporate strategies are top of mind at their level. Similar to the chief interviews and with *not* and *don't* in the top 10 most used words, this would suggest the interviews were more negative than positive.
LIWC	LIWC Positivity Index Score of 2.30.	Shows the interviews in the director category were less positive than those in the manager (6.7) and chief (3.79) categories, however, they were more positive than the vice president interviews (1.85). It is worth mentioning that the highest positivity index scores was in the director category at 13.1.
WORDij/ OptiComm	Strings with low average pair frequency: [0.5833] innovation -> people -> quality (3.5000) [0.7000] innovation -> people -> really -> quality (4.3333) [0.7262] innovation -> people -> right -> quality (4.6667) [0.7500] innovation -> not -> really -> quality (4.0000) Strings with high average pair frequency: [0.0455] innovation -> quality (22.0000) [0.5985] innovation -> people -> dont -> think -> quality (8.0000) [0.6534] innovation -> not -> think -> strategy -> quality (8.7500) [0.6534] innovation -> people -> think -> strategy -> quality (8.7500)	This could be interpreted as "When you think of innovation, people don't think quality" or "Innovation people don't think quality". There are other interpretations that could be extracted. Atlas.ti quotations will help identify key messages.
z-Test	Directors mention words *people, strategy* and *product* more often than vice presidents with z-scores of 2.094 ($\chi 2 = 58.56$), -2.434 ($\chi 2 = 8.966$), and -2.517 ($\chi 2 = 5.565$) respectively.	Directors are more concerned with people, strategy, and product when compared to what vice presidents discuss in the interview.
Atlas.ti / Key Quotes	*"High quality, innovation [means] always working, long life."* *"We have not embraced "failure""* *"[I]nnovation involves a certain amount of...risk-taking"*	

Vice President		
Tool/Function	**Output**	**Insight**
WORDij/ WordLink	The words *"quality"* and *"innovation"* are the most used words, with the words *"not"* and *"customer"* in the third and fourth positions, respectively.	Vice presidents mention quality and innovation often. These strategic areas along with customer are key areas of interest at this leadership level.
LIWC	LIWC Positivity Index Score of 1.85.	Shows the interviews in the vice president category were less positive than those in any other category.
WORDij/ OptiComm	Strings with low average pair frequency: [0.4000] innovation -> think -> quality (5.0000) [0.4500] innovation -> corporate -> quality (4.5000) [0.5000] innovation -> set -> quality (4.0000) [0.5000] innovation -> necessary -> quality (4.0000) Strings with high average pair frequency: [0.0625] innovation -> quality (16.0000) [0.2111] innovation -> deliver -> quality (9.5000) [0.3500] innovation -> simultaneously -> deliver -> quality (8.6667) [0.3611] innovation -> deliver -> simultaneously -> quality (8.3333)	This could be interpreted as "Innovation is necessary for quality" or "Innovation can be delivered simultaneously with quality"
z-Test	z-test comparisons can be found in the other leadership level analyses.	
Atlas.ti / Key Quotes	*Inhibitors of innovation are:* *"Everyone telling you that you can't. Fear of failure, what if it doesn't work. People need time and space to think freely and know that; a culture that says weird ideas are ok."* *"We need a culture to innovate"* *Culture required for innovation and quality to coexist:* *"Obsessive customer focus…all teams innovate"*	

QAPnet - Word Pair Correlation Summary – Innovation Definition

	Quality	Advanced Product Design	Both
Quality	+1.00		
Advanced Product Design	-0.316	+1.00	
Both	-0.365	-0.180	+1.00

QAPnet - Word Pair Correlations Summary – Quality Definition

	Quality	Advanced Product Design	Both
Quality	+1.00		
Advanced Product Design	-0.272	+1.00	
Both	-0.438	-0.280	+1.00

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ABSTRACT

UNDERSTANDING THE RELATIONSHIP OF INNOVATION AND QUALITY IN A FAST-CHANGING MARKET: AN AUTOMOTIVE INDUSTRY PERSPECTIVE

by

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December 2019

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In a time when the consumer electronics industry is getting new products to market at a rapid rate, automotive original equipment manufacturers (OEM) must identify ways of getting new products and features to customers faster and with high quality to maintain or increase market share. This accelerated product development process requires a positive relationship between conceptual design and quality in order for a firm to have high performance in strategic areas innovation and quality. The purpose of this dissertation is to research the impact that quality practices have on the advanced product development process. Specifically, this research is focused on the innovations that are an expected outcome of the advanced product development, or conceptual design, process in the traditional automotive industry. The conceptual model for this study was designed to understand how team factors including culture, shared meaning, information exchange along with the organizational complexity of interdepartmental interactions impacts firm quality and advanced product design performance. To investigate the relationship between quality and conceptual design or advanced product design teams, the study draws upon literature in the following domains: innovation, quality, and their intersection, organizational culture, organizational structure and networks, information exchange, and interdepartmental interactions.

This research uses a Convergent Parallel Mixed Methods approach where both qualitative data and quantitative data were collected then analyzed separately. The results of the study show that the quality and advanced product design teams perceive their culture type to be the same. Additionally, there are some differences in shared meaning of innovation and quality between the teams. Lastly, the relationship between interdepartmental interactions and firm performance requires additional research.

For theory, the research is expected to contribute to the literature in the area of innovation and quality with reference to the behaviors and practices that facilitate or obstruct the development of fast-to-market innovations that will simultaneously improve quality performance. In practice, the research will raise awareness by educating management about ways to deal with the challenges of introducing fast-to-market technologies and innovations during the advanced product design process, while ensuring a positive impact on product quality.

AUTOBIOGRAPHICAL STATEMENT

Donna L. Bell has spent the majority of her career in the automotive industry as an engineer and engineering leader. Her background includes contributions in product development, specifically module and electrical system design, purchasing as the buyer of automotive electronics and sensors, quality including Six-Sigma for electrical systems globally, sustainability in the area of vehicle electrification and smart grid interactions, advanced research design working in the fast-paced Silicon Valley ecosystem, and more recently in advanced technology and features strategy and planning. Donna's experience in these roles have helped to prepare her for this body of research.

Donna is a member of the 2011 Global Executive Track (GET) cohort in the Department of Industrial and Systems Engineering at Wayne State University. She holds a Bachelor of Science degree in Electrical Engineering from Lawrence Technological University in Southfield, Michigan. She also holds two Master of Science degrees in engineering, Electronics and Computer Control Systems (ECCS) and Engineering Management Master's Program (EMMP) from Wayne State University. Donna presented her preliminary research findings at the 2018 Institute for Operations Research and the Management Sciences (INFORMS) Annual Meeting.